



SEC. : BCEGH ROLL NO. : 078BCE178

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Ch 1 - Functional Requirement of Building

Archi code: NBC-206

As per IS (SP: 7-1970), A building is a structure for whatsoever purpose and whatsoever materials constructed and every part of thereof whether used for human habitation or not and includes foundations, plinth, wall, floors, roof, chimneys, plumbing and building services, verandah, balcony cornice or projection, part of a building or anything affixed thereto or any wall enclosing or any signs and space and outdoor display structures.

A permanent or temporary structure constructed with materials (eg- concrete, brick, wood, metal)

As per NBC: 206, that includes foundation, roof, chimneys, walls, floors, plumbing system, verandah, balconies and attached components like water tanks, septic tanks or outdoor structures. It encompasses all habitable or non-habitable spaces, whether residential, commercial, industrial or institutional.

Temporary structures like Tents, shamianas and Tarpaulin (tripl) shelters etc are not considered as buildings.

Types of Buildings

In detail: IS 875: Part II

- (1) Residential Buildings : building with sleeping facility, with or with cooking or dining or both facilities.
- (2) Educational Buildings : More than 8 hours per week assembly for academic purpose or education.
- (3) Institutional " → Building or part of it used for purposes such as a medical or care of person suffering from physical or mental illness.
- (4) Assembly " → Building or part of it where group of people gather for amusement, recreation, etc.
- (5) Business " → Building or part of it which is used for the transaction of business and for keeping the records of the business.

(6) Mercantile Building: Building or part of it which is used as shops, stores, markets and sale of merchandise, either wholesale or retail

(7) Industrial: Factory, Power-plant

(8) Storage / Parking: Building used for park vehicles, store goods, manufactured products, raw materials.

(9) Hazardous: Building or part of it which is used for storing, handling, manufacture or processing of highly combustible or explosive materials

Classification

Imp As per NBC 206, Types of Buildings

* Based on occupancy

Group A: Residential
(A1, A2, A3, A4)

Group B: Assembly (B1, B2)

Group C: Educational (C1, C2)

Group D: Hospital & Clinic (D1, D2)

Group E: Commercial

Group F: Office

Group G: Industries

Group H: Storage

* Based on storey and Height:

Group S1: General Building, 1-5 or 16m

Group S2: Medium Rise, 6-8 or 16-25m

Group S3: High Rise, 9-39 or 25-100

Group S4: Skyscraper

1.2 Heat Phenomenon in Building

Convection: Transfer of heat by moving air eg.

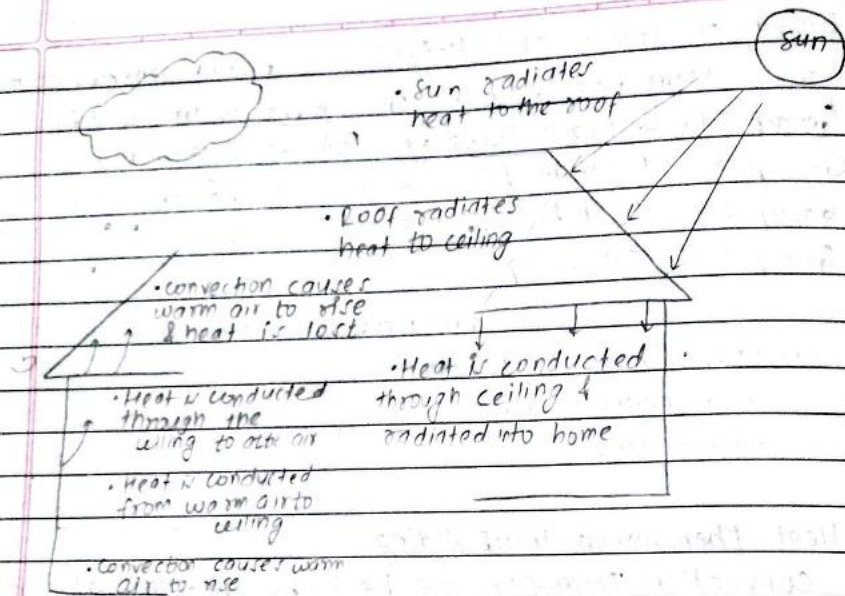
- warm air rises and transfers heat to the ceiling

Conduction: Transfer of heat through a solid material

eg. Heat is transferred from warmer sections of the walls and ceilings to cooler sections.

Radiation: Transfer of heat in the form of electromagnetic waves

eg. Heat is transferred from the roof to the ceiling



* Thermal performance of Building

* Factors affecting thermal comfort

* Thermal comfort: It is the condition of mind that expresses satisfaction with thermal environment & is assessed by subjective evaluation.

3S → strength, stable, satisfactory.

* Optimal thermal comfort requires the heat loss of human body to be in balance with its heat production.
State of heat balance of human body.

* Human response to the thermal environment depends to a great extent on the ease with which the body is able to regulate the heat balance in such a way that internal body temperature is maintained at 37.04°C.

* Factors affecting thermal comfort

(1) Environmental factors

- ✓ Air temperature
- ✓ Humidity
- ✓ Radiation
- ✓ Air movement

(2) Personal factors

- ✓ clothing
- ✓ Metabolic heat
- ✓ Wellbeing & sickness

(3) Design variables such as geometrical dimension of a building elements

* Thermal Design

It is the designing of various elements/devices of the building which effects thermal performance of the building.

* Thermal Design factors (Factors affecting thermal performance)

- (i) Geometric dimensions (walls, roofs; windows, etc.)
- (ii) Material properties (density, thermal conductivity)
- (iii) Weather data (temperature, solar radiation, wind speed)
- (iv) Building usage data such as lighting, equipments, etc.

* Some points for Insulation:

- (i) Walls (thickness, cavity wall, light coloured white wash or distemper)
- (ii) Roofs (white washed in summer, shining & reflecting material on top, application of insulating material)

✓ Approx. 22% of total energy consumed for building operation is used to heat & cool (commercial building) for residential building, the value is 25%.

* Thermal control of Building:

↳ can be made through Active solar system, passive solar system & Hybrid.

(1) Passive solar control system:

↳ In this system collection, storage or transportation of solar power is done without any use of mechanical means for cooling, heating & lighting.

✓ ↳ Simple technique is used like orientation, opening, insulation, site planning, materials, colour, vegetation, etc.

→ Maximize heat gain in winter & Minimize in summer.

→ Main living space face south for max^m winter sun.

→ Large windows on south & minimal on north.

↳ Natural means: → Roof overhang: Block high summer sun while allowing lower winter sun.

→ Insulation to obtain heat

(2) Active solar control system:

↳ with use of mechanical means

✓ ↳ solar water heater, air conditioning, forced ventilation, etc.

* Ventilation:

Defined as supply of fresh outside air into an enclosed space or the removal of inside air from the enclosed spaces

(odour + heat)

Ventilation is important for:

- (i) Resisting accumulation of carbon dioxide, inflammable gases, dust particles, bacteria, etc
- (ii) Prevention of odour caused by decomposition of building material
- (iii) Removal of smoke & foul smell generated by occupants
- (iv) Removal of heat generated by human body.
- (v) Prevention of suffocation condition in conference rooms, committee halls, etc.

* Functional Requirement of ventilation: (ETHQ)

- (1) Rate of supply of fresh air: Room should never contain more than 0.06% of CO_2 , this can be achieved by proper ventilation.

→ (Air movement or Air change)

✓ Air change = Air change per hour is the volume of outside air allowed in the room per hour to the volume of the room. $\left(\frac{\text{Volume air/hr}}{\text{Vol. room}} \right)$

IS code: Minimum = 1 per hour (below it no ventilation)

Maximum = 60 per hour (above it, discomfort to occupants due to high velocity)

Rough guideline for air space:

Air space (m^3)	Fresh air supply (m^3/h)
5.5	28.5
8.5	20.5
11 or upwards	17

(2) Temperature of air

→ It is desirable that incoming ventilated air must be cool in summer and warm in winter

→ Effective temperature indicates the temperature of air at which a person will experience sensation of same degree of cold or warmth as in quite air fully saturated at same temperature.

→ Common effective temperature = 20° in winter
= 23° in summer

(3) Humidity

→ Amount of water vapour present in air

→ Relative Humidity is defined as ratio of water vapour present in air to amount of water vapour if the air were saturated.

✓ → RH = 33 to 70% at working of 21°C is considered desirable

✓ → For higher temp^s, low humidity & greater movement of air is necessary for removing greater portion of heat from body.

(4) Quality of Air:

→ ventilated air should be free from impurities

→ Air in habitable room should never contain more than 0.06% of CO_2 .

→ pure air is necessary for the sustenance and improvement of health, for the perfect combustion of fuel and for the preservation of materials of which buildings are constructed.

* System of Ventilation

(1) Natural ventilation

↳ w/o using mechanical means

Rate

Rate of ventilation depends upon:

(a) Ventilation due to wind effects:

→ Rate of ventilation depends upon the direction and velocity of wind outside and size and position of openings

→ The rate of air flow through an opening due to wind blowing on the wall containing opening is:

$$Q = KAV$$

Q → Rate of air flow; m^3/h

K = Coefficient of effectiveness

A = Area of smaller opening in m^2

V = wind velocity in m/hr

Note: Wind velocity of Nepal, $V = 47 m/s$

(Q) If 2 square opening of size $0.36m$ with a wind speed of $V = 5 km/hr$ blowing included at 45° in a room ($4m$ size and height). Calculate air change per hour.

→ Solⁿ:

$$V = 5 km/hr$$

$$V = 5000 m/hr$$

A.s, Area of larger opening = 1 (same)

Area of smaller opening

$\Rightarrow K = 0.3$ for wind blowing at 45°

Now,

$$A = 0.36^2 = 0.1296 m^2$$

Then,

$$Q = KAV = 0.3 \times 0.1296 \times 5000 = 194.4 m^3/hr$$

$$\text{Air change} = \frac{Q}{\text{Vol. of room}} = \frac{194.4}{4 \times 4 \times 4} = 3.0375 \text{ hr}$$

#

Ventilation

Air conditioning

Purpose: Replaces stale indoor air with fresh air

Controls temp, humidity & air quality

Type: Natural or Mechanical

Always mechanical

Energy use: Low Medium

High

Humidity control: Not directly controlled

Maintains required humidity

Temperature: Not regulated

Precisely controlled

Air quality: Improved by introducing fresh air

Improved via filtration system

Eg: Windows, exhaust fans

Split AC, HVAC system

Cost: Low to Medium

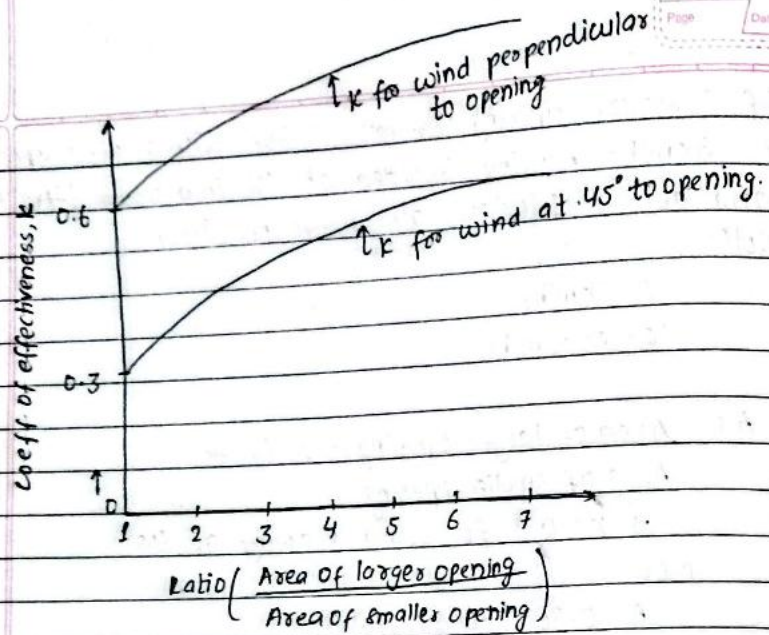
High

Sustainability: More eco-friendly

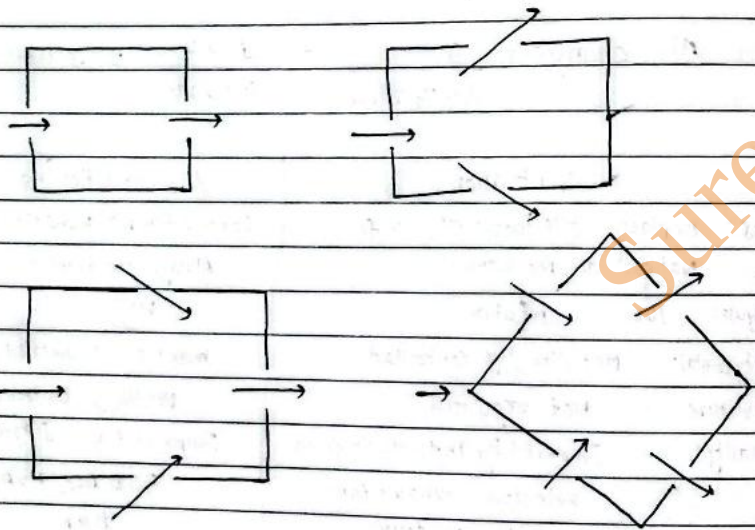
Less sustainable w/o renewable

Comfort level: Basic

Thermal comfort all season



Graph: value of coeff of effectiveness vs air opening ratio.



$$\Phi = 640 C A h (t_i - t_o)^{0.5}$$

inlet

outlet

* Ventilation due to stack effect

→ The rate of ventilation is affected by convection effects arising from temperature difference inside and outside of the room and the difference in the height b/w outlet & inlet opening.

The rate of air flow arising from temp^r difference b/w inside & outside:

$$\Phi = 640 C A h (t_i - t_o)^{0.5}$$

where,

Φ = Rate of air in m^3/hr

C = coefficient of effectiveness

— 0.65 for general condition

— 0.5 for unfavourable condition

A = free area of inlet opening

h = vertical ht. difference b/w inlet & outlet in m.

t_i = avg. inside temperature in $^{\circ}C$.

t_o = avg. outside temp^r in $^{\circ}C$

~ Note: Stack effect is negligible to wind pressure effect

* General rules of Natural ventilation

(2) Mechanical Ventilation

- ↳ Use of mechanical equipment for effective air circulation.
- ↳ This system is costly.

Types:

(i) Extraction System:

- creation of vacuum in the room by exhausting vitiated inside air by means of propeller type of fans (exhaust fans).
- permits fresh air to flow from outside to inside through Tobin tube or windows.
- Useful in removing smoke, dust, odours, etc.

(ii) Plenum System (Supply System)

- ↳ Fresh air is forced into room

(iii) Extraction Plenum System
↳ Combination

(iv) Air Conditioning System

- Generally natural ventilation is preferable but mechanical ventilation may be necessary where:
 - The building is too deep to ventilate from the perimeter
 - Local air quality is poor, for example, if a building is next to a busy road
 - Local noise levels mean that windows cannot be opened
 - The local urban structure is very dense and shelters the building from the wind.
 - Air cooling or air conditioning systems mean that windows cannot be opened.
 - Privacy or security requirements prevent windows being opened.
 - Internal partitions block air paths.
 - The creation of drafts adjacent to building openings

- Generally narrow opening kept near in roof or in height near roof
- It may be totally opened or provided with closing shutters.
- The necessary rate of change of air will be depending on no. of people and activity.
- In kitchen and bathroom it helps to remove smoke, smells and reduce condensation.

- In Nepal context the law says at least one side of water closet and bathroom must face outside for well ventilation and the shaft must be at least 1.9m

- NB
- For natural ventilation, at least of $\frac{1}{20}^{\text{th}}$ area of external opening to floor area must be provided.

- When such ventilation requirements are not met, the same shall be assured via artificial ventilation.

* Types of ventilations

• Natural

- (i) Side hung
- (ii) Bottom hung
- (iii) Horizontally pivoted
- (iv) Vertically pivoted
- (v) Top hung
- (vi) Vertically sliding or horizontally sliding
- other: roof vent

• Artificial

• Air conditioning

- Best artificial ventilation where air volume is filtered, heated or cooled, humidified or dehumidified, etc.
- Process of treating air is as to control simulate temperature, humidity, purity, distribution, etc. to meet the comfortable requirement of the space.
- Most comfortable environment for living and working space

• Advantages

- Maintain health and comfort from filtration and simulated conditions.
- Improve quality of products in certain industrial processes such as artificial cotton, clothes, food processing, etc. and also a comfortable working environment for workers.

→ Avoids sluggish or lethargic mood of the people which leads to spending quality time.

→ Boost efficiencies and working environment in shops, malls, banks, theaters, etc.

→ For relaxed and comfortable journeys in closed vehicles like trains, planes etc.

→ For lab and research context where required environment is to be simulated like temperature, relative humidity, etc.

• Types

- (i) Mechanical inflow and exhausts
- (ii) Conventional ACs
- (iii) Portable air conditioners

Lighting

- Lighting inside the building is necessary to illuminate the interior and its contents to perform the task.
- Gen. light is band of electromagnetic radiations of 380-780nm
- Good lighting is important for efficient work
- Inadequate or high lighting or improper (flickering) may cause irritation, headache, stress, dizzy, etc

As per NBC:

- All habitable rooms (not less than 2m x 2m) shall have admission of light through external wall openings ≥ 1 th the floor area of the room.

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- Admission of light is permitted through internal courtyard having minimum dimension of 3m x 3m.
- No portion of the room shall be considered naturally lighted if it is more than 7.5m from the opening.
- If such requirements are not fulfilled then artificial lightening devices must be installed meeting the same criteria.

• Natural lighting (Day light)

- Source is sun and gives about 100 flux and radiation about 1 kW/m^2 is received.
- Quality of light depends on length of the day, weather, location, seasons, etc.
- Factors for effecting penetration of light through opening depends on type, size, placement, orientation, etc.
- Sky light may be direct or overcast thus overheating and glare have to be avoided.
- Quality is proportional to area of glass windows relative to floor area.

• Day light factor

- Ratio of internal illumination in a certain point in building with the simultaneous outdoor illumination.
- Expressed in %
- Daylight varies considerably in intensity both hourly and daily due to rotation of the earth and consecutive relative position of the sun.

- Generally considered for the artificial lighting and given by

$$DF = \left(\frac{E_i}{E_o} \right) \times 100 \%$$

E_i = Indoor illumination at a point

E_o = Outdoor illumination from unobstructed sky
(for overcast or non-sunlight)
direct

Light can reach a room via through a glazed window, roof light, or other aperture via three paths

Also,

Daylight Factor:

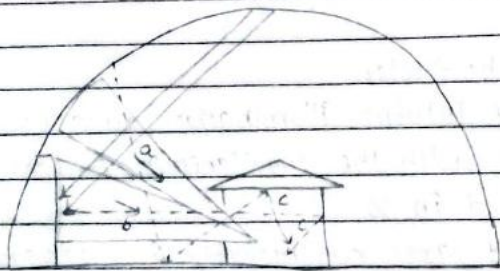
$$DF = SC + ERC + IRC$$

where,

SC → sky component

ERC → Externally reflected component

IRC → Internally " "



a → sky light b → ERC c → IRC

If $DF = 6\%$ and $E_0 = 8000 \text{ lux}$

then,

$$DF = \frac{E_i}{E_0} \times 100$$

$$\text{or } 6 = \frac{E_i}{8000} \times 100$$

$$\Rightarrow [E_i = 480 \text{ Lux}]$$

• Good visibility depends on:

→ characteristics of work

→ Eyesight of workers and occupants

→ Speed and accuracy required for work

→ Ease and comfort for working.

Glare: condition of vision which there is discomfort or a reduction in the ability to see significant objects or both due to an unsuitable distribution or range of illumination or to extreme contrast in space or time.

• Guidelines for good lighting:

→ Broad opening gives better distribution of lighting

→ Openings on two opposite sides will give greater uniformity

→ Coarse lighting with openings and walls tends to increase the diffused light in room.

→ Deep openings and avoiding direct sunlight minimizes the glare

→ Openings with sunshades, louvers, etc minimize direct sunlight

→ Identify, where and when lighting is needed.

→ Direct light downward, by choosing correct type of light fixtures.

→ Select correct light source (bulb type)

→ Utilize "shut off" controls such as sensors, timers, motion detectors, etc.

→ Limit the height of fixtures.

→ Use correct amount of light.

→ Design interior lighting so that it does not illuminate outdoors.

• Artificial lighting

- The primary purpose of artificial lighting systems is to provide sufficient illumination for the performance of visual tasks.

Requirements

- The source of light should be steady.
- Glare should be eliminated.
- Inconvenient shadows should be avoided.
- The degree of illumination must be sufficient suitable for the particular task.
- Lighting should not cause excessive heat.

Sound and Acoustics

Sound: Vibrations (successive compression and rarefaction of molecules) that travel through the air or any other medium and can be heard when they reach a person's or animal's ear.

Acoustics: the branch of physics concerned with the properties of sound. And also the properties or qualities of room or building how sound is transmitted in.

It creates the optimum conditions for producing and listening to speech and music.

Provides insulation for dissipation and cancellation of external noise.

Noise: a series or combination of loud, confused sounds, especially when causing disturbance
↳ undesirable/unwanted sound.

• Reactions given for sound:

- ↳ Reflection: from wall, floor, ceilings, etc.
- ↳ Absorption: by walls, floors, ceilings, furnitures, curtains, soft materials, foams, bodies, etc.
- ↳ Transmission: to adjacent room, corridors outside or inside, etc.
via walls, partitions, windows, etc.

• Classification of sound:

Depends on position of source:

(i) Airborne sound: transmitted through air to ear
↳ Like sound for inside to inside, inside to outside, or outside to inside via air through openings and ducts.

(ii) Impact sound:

↳ Transmits first through the structure and then into the ears.
↳ Footsteps, falling of objects, furniture movements, etc.
↳ Often sharp and taken as noise.

• Noise and its effect:

↳ Annoy or irritation
↳ Disturbance of peace and concentration in work and sleep.
↳ Interference in conversation
↳ Damage of ears and health impacts

Noise control and constructional precautions to reduce noise:

→ Isolate sound sources
→ Orientation (no opening towards outside noise source)
→ Properly planned rooms
→ Furnishing and other absorbing materials in room.
→ Partition type as rigid or movable
→ Control impact sounds like using carpets, wheels, etc.
→ Use of headphones and earplugs in high sound like in factories.

* Defects due to reflected sound:

→ Echoes (Echo is defined as the repetition of a sound caused by the reflection of sound waves from a hard surface back to the listener. Direct sound wave is already heard and thus there is repetition)

→ Reverberation (Repetition of sound in an enclosed space, after the source has stopped and then decay as the sound is absorbed by the surfaces of objects in the space)

→ Sound foci (Concentration of reflected sound at a certain spot that creates sound of large intensity)

→ Dead spots (Due to sound foci effect, sound at some points are insufficient to hear)

→ Insufficient loudness (Defect caused by lack of sound reflecting flat surface near the source and excessive sound absorbing devices)

→ Exterior noise (Defect caused by lack of proper sound insulation)

↳ Reverb is necessary to enhance the sound but excess is damaging the clarity.

- * In comparison to a distinct echo, that is detectable at a minimum of 50 to 100 ms after the previous sound, reverberation is the occurrence of reflections that arrive in a sequence of less than approximately 50 ms.

As time passes, amplitude of reflections gradually reduces to non-noticeable levels.

Reverberation is not limited to indoor spaces as it exists in forests and outdoor environment where reflection exists.

• Sound absorbent:

(i) Porous material: Sound wave enters the pores and traps inside and dies out.

(ii) Resonate panels: Semi-hard porous fiber panels with air gap between them and wall acts as sound absorbent.

The vibration is absorbed and is damped in air cavity in it.

Air cavity can be filled with porous material to enhance the damping effect.

(iii) Cavity resonators: Chamber with narrow opening and absorption occurs by resonance of air in it.

(iv) Composite types: perforated panels fixed with air space ~~and~~ containing porous absorbents. Contains 2 or more different types of absorption method and materials.

* Sound Insulation

↳ blockage of sound

It can be done by:

1. Wall insulation:

↳ insulation is governed by net sound provided and efficiency with which it serves as barrier.

↳ 4 inch wall with plaster in both side helps to reduce average of 50 db.

↳ Thickness and wt. can be reduced by making composites.

(i) Rigid and massive homogeneous walls

(ii) Partitions by porous materials

(iii) Double wall partitions

(iv) Cavity wall type construction

2. Floors insulation

↳ Resist impact noise easily

↳ sound absorption coeff. for plain cast concrete is about 0.02 indicating that about 98% of the sound energy is reflected by the surface.

↳ The more the concrete weighs, or the denser the concrete, the more sound insulation rating.

3. Windows & Doors insulation

4. Insulating sanitary fittings Insulation

5. Insulation of Machine.

Can sound-insulating material be a poor sound absorber?

- Yes, absolutely
- Both different properties
- Sound Absorption: Reduces echoes & reverberation inside a room.
- Sound insulation: Prevents sound transmission b/w rooms.
- Dense Materials (eg. concrete): Excellent insulator, but reflect sound.

→ Porous Materials (eg. foam): Good absorbers but poor insulation

→ Design Strategy: Use dense material for insulation & soft finishes for absorption

→ Studios use both - dense wall and acoustic panel.

→ A material can block sound well yet make interior noisy.

H2. Sound barriers: Installed across plane - floor, slab or ceiling,

↳ eg: Acoustic ceiling panels, floating floors, insulated slab b/w stories

V1. Sound barriers: erected upright - like walls or partitions b/w rooms,

↳ eg: Cavity walls with insulation, Drywall partition with acoustic fill, brick & concrete block wall.

Materials use: Gypsum board, mineral wool, glass wool, concrete, foam.
Use acoustic sealants to block sound leaks.

Orientation and Planning

* Orientation:

→ Setting of plan of the building on its site with reference to the directions

→ Building orientation refers to the way a building is situated on a site and the positioning of windows, roofline and other features

→ Factors to be considered for the planning and orientation of the Building:

1. Sun exposure of the Building

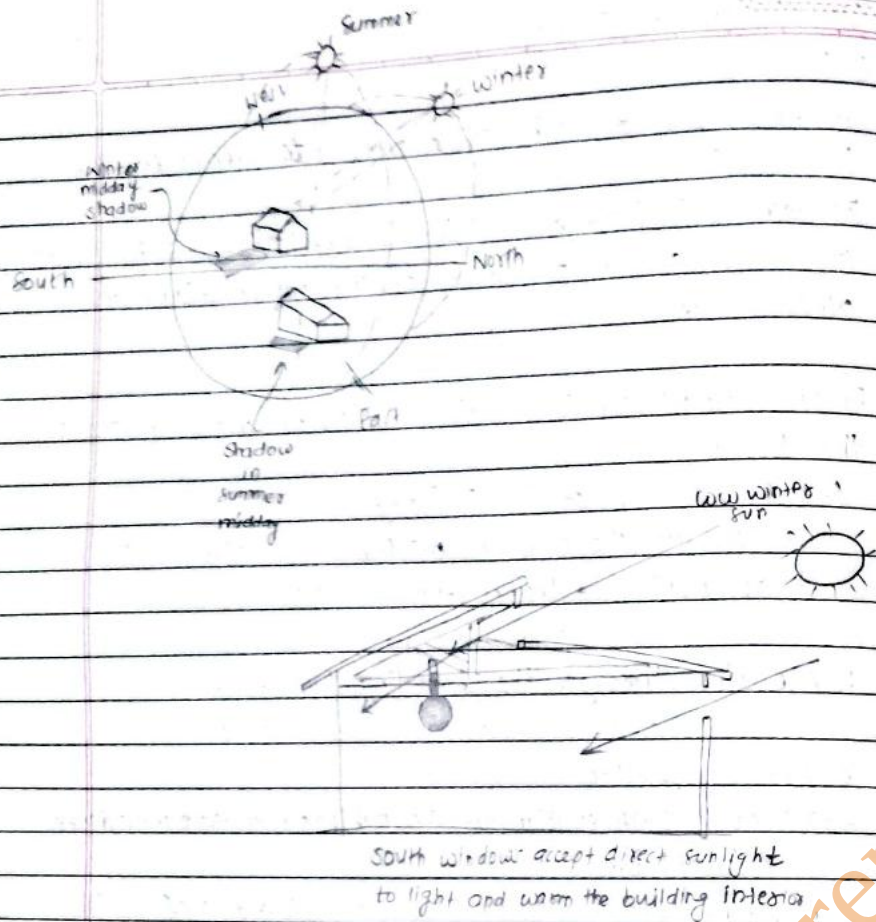
- (a) Calculate the position of the sun relative to the opening
- (b) orientation of the windows.

2. Air flow through the building

3. Sensory factors

- (a) Views: Consideration of Desirable or undesirable view for orientation
- (b) Sound: Level, Quality and source of sound affect the orientation.

(4) Extensive and continuous shadowing of ground due to large and tall buildings.



* Principles/Criteria for the site selection:-

- Choose the better site or adjust with design to match site.
- Purpose and extent of privacy desired
- Site should be located in fully or fast developing locality.
- All civil amenities (facility) should be nearby
- Should be aware of By-laws of buildings
- Should meet the requirement of owner with restrictions applied.
- Plot should not have sharp edges.
- Proper drainage should be available
- Bearing capacity should be adequate
- Healthy living and working conditions.
- Should be away from industrial area, high flooding areas, water logged areas, bad drain maintained, slum, etc.
- Legal and Financial aspects should be followed.
- Advantage of nature (light, wind, humidity, climate, weather, etc)

* Bye-laws:

- Standards and specifications designed by a local authority for maximizing safety to the workers during construction, comfort and good health to the user as well as enough safety to the general public

→ Why it is needed?

- The building bye-laws set standards for building works.
- Their aim is to ensure the health and safety of people in and around buildings by setting requirements for building design and construction
- The bye-laws also promote energy efficiency and aim to improve access for disabled people.

→ Bye-Laws govern the following aspects:

- (a) Set-back / Building line
- (b) Floor space index / Built-up area
- (c) Open space requirements
- (d) Size of rooms
- (e) Height of rooms & buildings
- (f) Lighting & ventilation
- (g) Water-supply & sanitation
- (h) Structural Design

* Planning

- is to arrange all the required units of building on all floors and at level according to their functional requirements making best use of the space and resource available for a building.
- Shape of such a plan is governed by several factors such as structural integrity, climatic conditions, site locations, accommodation, requirements, local bye-laws, surrounding environment, etc.

• Factors to be considered during planning:

(i) Aspect

↳ orientation of the building

↳ sunlight and door/windows arrangement

↳ should be such that it enables the family members to live comfortably

→ (such a way that plenty of sunrays, breeze can enter) into the house.

↳ should be well-ventilated and well-lighted by the proper placement of door and windows

↳ comfort, hygiene and pleasant view.

(ii) Prospect

↳ is the view from outside of a house

↳ give a feeling of cheerfulness to the people living in it and give good impression to people outside.

↳ should reveal pleasant features and hide unpleasant and undesirable features of the house

↳ Eg. small projection or bay window can have a good outlook as well as helps in providing breeze, light and sunlight to the room.

(iii) Privacy:-

↳ a state in which one is not observed or disturbed by other people

↳ privacy can be maintained in ways:

→ External

→ Internal

(iv) Grouping

↳ arrangement of different units one after another correlating with one another.

↳ common room grouped near

↳ washroom should be easily accessible for all

(v) Sanitation

- ↳ proper lighting, ventilation, cleanliness and other Sanitary convenience in the house
- ↳ Overall health and hygiene of the building

(vi) Circulation

- ↳ Internal movement of people and things inside the building
- ↳ within same floor or level $\Rightarrow$ Horizontal
 - ↳ passage, door, hallway, etc
- ↳ with different levels or floor $\Rightarrow$ Vertical
 - ↳ stairs, lift, escalator, steps, ramps, etc

(vii) Economy

- ↳ Building should have minimum floor area with maximum utility

(viii) Flexibility $\rightarrow$ Future extension and safety

(ix) Roominess $\rightarrow$ space of a room (rectangular size is more convenient)

(x) Others

- Practical consideration
 - $\rightarrow$ Most practically possible and useful
 - $\rightarrow$ strength and stability
 - $\rightarrow$ Effective and beauty
- Spatial organization
 - $\rightarrow$ size
 - $\rightarrow$ scale
 - $\rightarrow$ proportion
 - $\rightarrow$ relationship
- Functional organization
 - $\rightarrow$ zoning: divided into several smaller zones as per their functional requirement to society
- Physical imagery
 - $\rightarrow$ Form
 - $\rightarrow$ Space
 - $\rightarrow$ Light
 - $\rightarrow$ Color
 - $\rightarrow$ Texture
 - $\rightarrow$ Patterns

* Context:

↳ In terms of the built environment, 'context' can refer to the conditions which surround a particular site or project, and to which it should relate and connect to in some way.

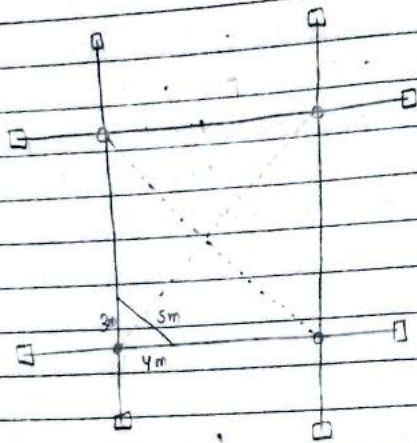
↳ The buildings and structures that make up the built environment do not exist in isolation but are conceived and designed in order to respond to, support and enhance their surroundings.

* Setting out of Building

- Before the commencement of the excavation of trenches for foundation, a layout plan is made.
- The process of measuring the building plan at the site and fixing of excavation line of all the walls, pillars of the plan is called site-layout work.

* Process of Setting Layout Plan:

- site clearance is done
- Details of the foundation trenches and site plan are noted on paper.
- Make the centre line of the longest outer wall of building by stretching a string between wooden pegs driven into its ends which is then used as a reference line marking the center lines of other walls of the building.
- The center line of the other wall that is perpendicular to the previously made.
- Pegs are driven into all control points of the wall center lines.
- Check by measuring opposite lengths of corners diagonally. If both of the length equals then setting is OK.



Moisture & its movement through building components and damp proofing.

→ Moisture: water particles

→ Source of moisture:

- Rain water
- Ground water
- Water from condensation
- Water from leaks and faults in water systems

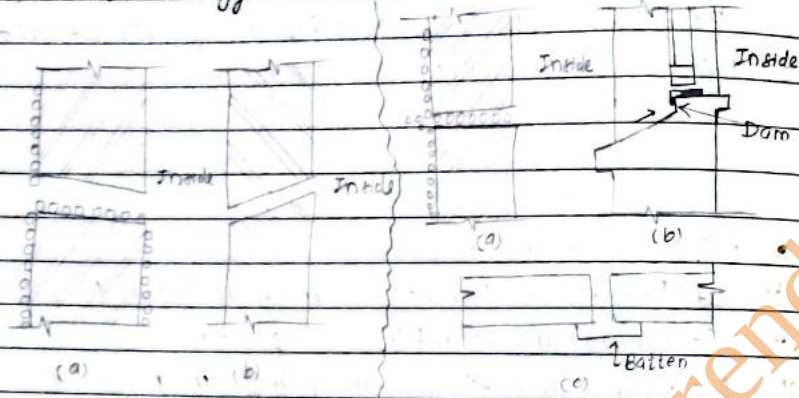
→ Absorption by building material, capillary action of granular materials of various elements, faulty design of structure, poor workmanship or by use of defective materials, moisture is transferred

• Effects of moisture:

- (i) Efflorescence (disintegration of material to powder)
- (ii) Softening and crumbling of plaster
- (iii) Bleaching and flaking in paints in patches.
- (iv) Warping, buckling and rotting of timbers.
- (v) Corrosion of metals
- (vi) Electric short circuiting and damages in electrical fittings
- (vii) Damage sound and thermal insulation
- (viii) Growth of fungus and termites (biological infestation)
- (ix) Unhygienic conditions

• Forces that move water are:

- (i) Capillary Action
- (ii) Wind loads (momentum of water particles due to wind)
- (iii) Surface tension of the building components.
- (iv) Gravity
- (v) Air pressure Differential $\rightarrow$ Inside and outside pressure difference cause flow via microscopic holes
- (vi) Diffusion: difference in vapor pressure
- (vii) Kinetic Energy

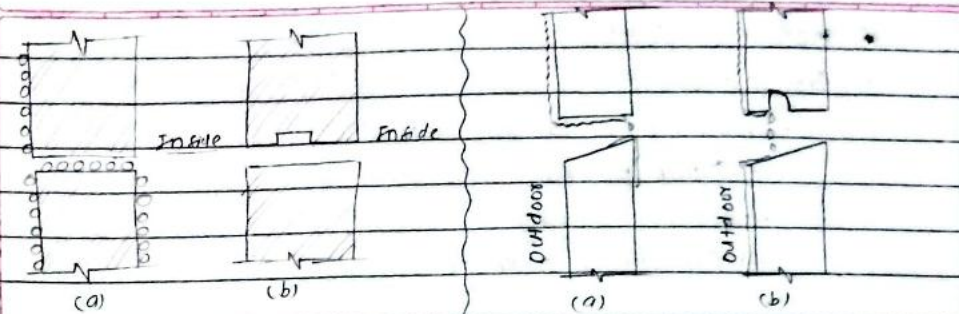


(a) Movement of Moisture due to Gravity Force

(b) Prevention of Moisture Movement due to Gravity Force

(a) Movement of moisture due to K.E

(b) & (c) Prevention of Moisture movement due to K.E.



(a) Movement of Moisture due to Capillary Action

(b) Prevention

(a) Movement of moisture due to Surface Tension

(b) Prevention

* Moisture Control

• Ground water control

- Water from ground
- Damp proofing
- Water proofing
- Subsurface drainage

• Rain Control

- Capillary break
- Obstruction in horizontal opening
- Drip edge or roof on horizontal opening
- Use of flashing

• Vapor control

- By Diffusion
- By air transport

* Flashing refers to thin pieces of impervious material installed to prevent the passage of water into a structure from a joint or as part of a weather resistant barrier system. In modern buildings, flashing is intended to decrease water penetration at objects such as chimneys, vent pipes, walls, windows, and door openings more durable and to reduce indoor mold problems.

* Water resistant barrier, redirecting water away from seams, joints or intersection where water penetration is likely.

Damp Proofing

- ↳ Application of various materials or membrane that repels the dampness/moisture.
- ↳ Treatment of a surface to retard the absorption of moisture in the absence of hydrostatic pressure.

↳ DPC: Damp proof course

- ↳ Flexible materials like bitumen, polythene, sheets, copper, etc.
- ↳ Semi rigid or mastic asphalt
- ↳ Rigid as bricks, stones, cement concrete, slates, etc.

DPC in buildings

Horizontal DPC

- ↳ Plinth
- ↳ Basement floor
- ↳ Roof
- ↳ Parapet wall cover

Vertical DPC

- ↳ Basement wall
- ↳ Outer surface of wall
- ↳ Surface of parapet wall

Methods of Damp proofing

1. Membrane damp proofing

Continuous layer of impervious material which is provided in b/w source and part of the structure.
Eg. plastic sheet, metal sheet, etc.

DISC 4P

- Use of DPC
- Integral damp proofing
- Surface treatment
- Cavity wall construction
- Guniting
- Pressure grouting

2. Integral damp proofing

- ↳ Adding the certain component to the concrete to the mortar during the process of the mixing to make it impermeable by filling the pores through the chemical action.

3. Surface treatment: Application of the water repelling layer substance on the surfaces.

4. Cavity wall construction: Main wall of a building is shielded by an outer skin wall, leaving a cavity b/w them.

5. Guniting: Deposition of the layer of rich cement mortar by pressure to exposed surface of wall.

6. Pressure grouting

- ↳ Forcing cement grout, under pressure into cracks, voids, fissures, etc. present in structural components of building or in the ground.

Materials for DPC:

- ↳ Hot Bitumen
- ↳ Mastic Asphalt
- ↳ Bituminous Asphalt
- ↳ Metal sheets
- ↳ Plastic sheets
- ↳ Stones; Mortar, Bricks, Cement Concrete, etc.

* Moisture control

• DPC

- ↳ below grade water proofing
- ↳ strong to resist hydrostatic pressure of ground but easily affected by weather.
- ↳ Used below ground level

• Above grade water-proofing:

- ↳ cannot resist water pressure but can withstand weather, used above ground and exposed area

• Flashing

- ↳ materials to redirect water entering through the building skin and exterior

• Sealant

- ↳ Are flexible materials applied in joints or other places and components for water proofing and environment control
- ↳ Eg. silicon gums, water proofing cement in joints, bitumen, etc

• Materials used for vapor barriers:

- ↳ unpainted gypsum board & plaster
- ↳ Fibre glass insulation
- ↳ cellulose insulation
- ↳ Expanded polystyrene
- ↳ Extruded polystyrene
- ↳ Aluminium foils
- ↳ Oil based paints

* Water Proofing

→ Treatment of a surface to prevent the passage of liquid water in the presence of hydrostatic pressure.

• Positive side water proofing:

- ↳ Positive side is the same side of structure as the source of water
- ↳ Most effective solution

• Negative side water proofing:-

- ↳ Negative side is the opposite side of the source of water. (For sub-surface water)

DOORS

A door may be defined as an openable barrier secured in an opening left in a wall for the purpose of providing access to the users and goods to pass in and out of the spaces

It consists of framework to fix a panel/shutter with hinge or other supports such that it can be opened for entry and exit to space and closed for privacy/to not allow passage

It consists of two parts - Frame and shutter

Frame

- In general, frame has vertical & hz. members
- Htz member on top of post is head, and it may or may not have projection called horn.
- Vt member is called post.

Shutter

- For shutters, Htz top and bottoms are also called rails
- Vt. post as stile if in sides and mullions if in middle
- Shutter is the leaf fixed on the frame
- Shutter fixing method and types varies as per use and demand
- Shutter number can also vary.

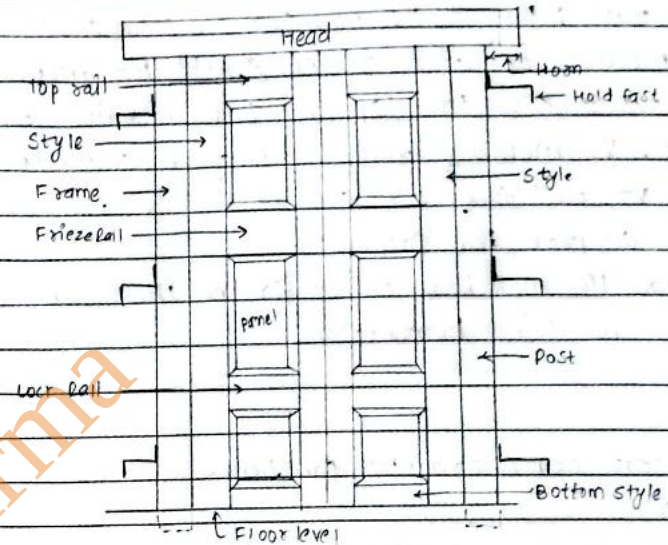


Fig. Components of Door

Technical Terms of Doors and Windows

1. **Frame:** consist of a group of members which form a support for a door and a window
2. **Shutter:** openable part of a door or window and is an assembly of styles, panels, and rails
3. **Head:** topmost hz. part of a frame
4. **Rébate:** A depression made inside the door frame to receive the door shutter.
5. **Sill:** lowermost part of the window.
6. **Style:** vertical outside member of a shutter
7. **Top rail:** Topmost hz. member of shutter
8. **Lock rail:** Middle hz member of a shutter where locking arrangement is fixed.

9. Bottom rail: lowest hz member of a shutter
10. Intermediate or cover rail: Added hz member fixed b/w the top and bottom rails of a shutter
11. Mullion: Vt member running through a shutter
12. Jamb: Vt wall face of door or window opening which support the frame
13. Transome: Hz member of a frame that sub-divides a window horizontally

* Important considerations for Doors

1. Purpose

↳ To serve as connecting link b/w various internal parts of building as well as outside world.

↳ The no. of doors shall be kept minimum, as more numbers of doors will cause obstruction and reduce the effective usable carpet area of the room.

↳ NBC 206-2015:

• In case of Assembly and Educational buildings minimum of two doors shall be provided if the no. of occupants in the room is greater than 50.

• Exit doorway of Assembly buildings shall be openable w/o a key from inner side

2. Size

↳ In general, a door should have dimensions such that the movement of largest object likely to pass is possible

↳ NBC 206: 2015:

• No exit door, inclusive of frame, shall be less than 1m in width and 2.1m in height except in case of residences where the min^m size of exit door shall be 0.9m in width by 2m height. The width of doors of rooms which do not form part of general habitation or exit medium such as toilets and verandah is permitted to width of 0.75m.

• The width of the doorway, shall be measured in the multiple of 500mm and calculated using table 2

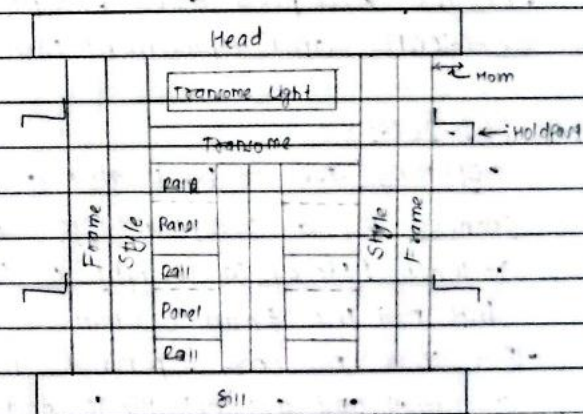


Fig. components of window

3 Location

↳ The location of doors is generally fixed by Architect of the building.

↳ NBC 206-2015:

• The max^m travel distance to exits or stairways from any point within the single floor level shall not be more than 30m for all types of building except when external corridor of 15m or more is part of route, in which distance may be increased to 40m.

However, it may be noted that external corridor are not allowed as medium of passage in case of High-rise buildings unless they are fully enclosed by a glazed medium in which case it is considered as enclosed.

• Exits shall be arranged in a way that they may be reached w/o passing through another enclosed, occupied area except in case of residential and apartment buildings.

↳ NBC 202-2015:

• Openings are to be located away from inside corner by a clear distance equal to at least $\frac{1}{4}$ of the height of the opening, but not less than 600mm.

• (For stone masonry) Openings should be as small and as centrally located as practicable.



Ventilators, where used, shall be 450x450mm or smaller. Top of openings in a storey should preferably be at the same level, so that continuous hz. band can be provided over them that includes the lintels throughout the building.

4. Material

↳ wood, glass and plywood and metals

↳ most common.

5. Other requirements

↳ NBC 205-2015:

• (For non-load bearing wall of RCC framed structure)

Provide a hz. RC band through the wall at the lintel level of doors and windows and at window-sill level in each storey as given

- Longitudinal → two bars 8mm ϕ (Fe415) anchored fully in the RC column abutting the wall

- Transverse → links 6mm ϕ (Fe250) stirrups at every 150mm.



↳ For safety glazed shutters of an external door should be provided with steel grill of suitable design

Types of Doors

> Classification Based on Materials used

1. Wooden Doors

- (i) Battened and Ledged
- (ii) Battened, Ledged and Braced
- (iii) Battened, Ledged and Framed
- (iv) Battened, Ledged, Framed and Braced
- (v) Framed and Paneled
- (vi) Glazed or Sash
- (vii) Flush
- (viii) Louvered

2. Metal Doors

- (i) Hollow Metal Door
- (ii) Steel Plate Door
- (iii) Corrugated Steel
- (iv) Rolling Shutters
- (v) Collapsible Door

3. Composite Doors

- (i) Metal covered Door
- (ii) Revolving "
- (iii) Sliding "
- (iv) Telescopic "
- (v) Swing "
- (vi) Fire check "

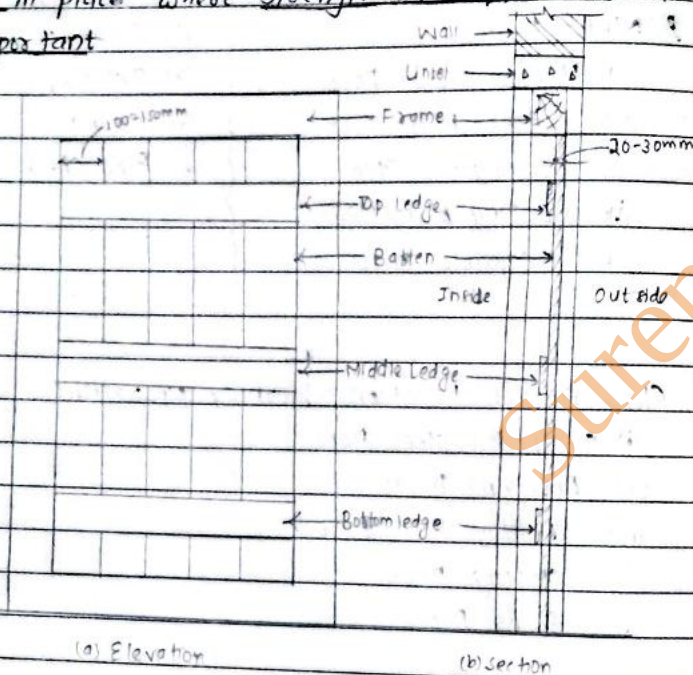
> Classification Based on Working Operations

- (i) Collapsible Steel Door
- (ii) Revolving Door
- (iii) Rolling Steel Door
- (iv) Sliding Door
- (v) Swing Door

Wooden Doors:

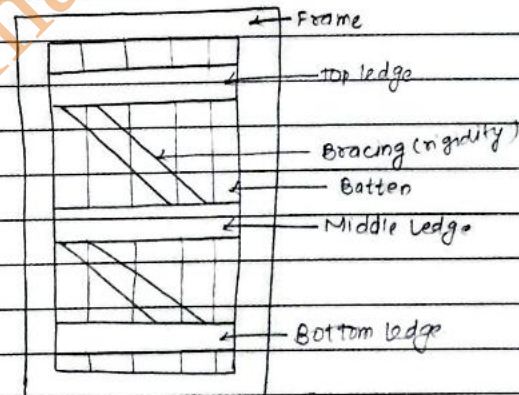
1. Battened and Lugged Door

- A lugged door is formed of the vertical boards, known as the battens, which are secured by horizontal supports, known as the lugs as shown.
- Battens are 100-150mm wide and 20-30mm thick.
- The lugs are generally 100-200mm wide & 30mm thick.
- 3 lugs are generally given at top, middle and bottom.
- The shutter is hung on the frame by T-hinges which are fixed on the lugs.
- Used in places where strength and appearance are not important.



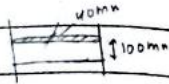
2. Battened, Lugged and Braced Door

- Similar to lugged door except that the diagonal members, known as braces, are provided.
- width of batten = 100-150mm & thickness gen. 30mm.
- Bracing gives rigidity and are used in wide openings.
- Bracing must be sloped upwards from the hanging side as they have to work in compression and not in tension.



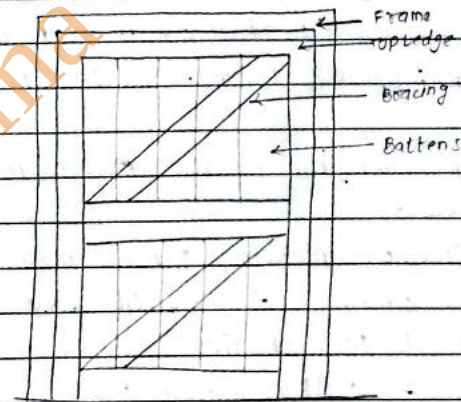
3. Battened, Lugged and Framed Doors

- ↳ A frame is framework is constructed for shutters to make the door stronger and better in appearance
- ↳ The styles provided to make the framework are generally 100mm wide & 40mm thick.
- ↳ Battens and ledger are provided as mentioned in previous door in space remained after construction of framework.



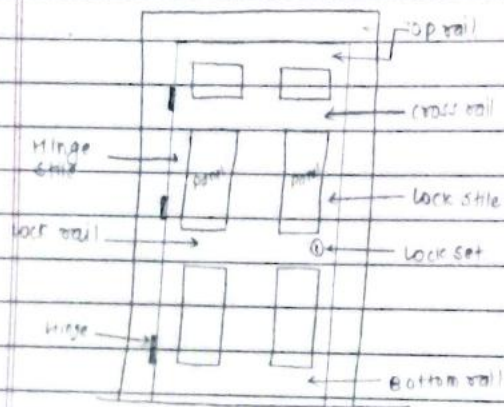
4. Battened, Lugged, Framed and Braced Doors

- ↳ Similar to above type door except that the bracer are provided.
- ↳ More durable, stronger and hence it can be adopted for external use and wide doors as they are rigid.
- ↳ The brace should incline upwards from the hanging side as they have to work in compression.



5. Framed and paneled doors

- ↳ The most usual variety of door and consists of a framework in which panels are fitted.
- ↳ Panel is flat rectangular component made of wood that is set into the door.
- ↳ This type of door reduces the tendency of shrinkage and presents a decent appearance.
- ↳ The thickness of shutter depends upon various factors such as type of work, situation of door, number of panels, etc. In gen. 30mm - 40mm. The thickness of panel is about 20mm.
- ↳ Panels secured in position by grooves made inside the edges of the framework.
- ↳ The number and size of panels, depend upon the architect design or owner's desire, gen. varies from 1-6.
- ↳ Small opening → single leaf shutters
Large or wide opening → double-leafed shutters



6. Glazed or Sash Doors

- ↳ To admit more light, in addition to that coming from the windows, the fully glazed or partly paneled and partly glazed doors are used.
- ↳ The usual glazed portion to paneled portion is 2:1.
- ↳ The glass is fixed in the door by wooden beads fixed to the frame.
- ↳ To increase the area of glazed portion the width of styles above the lock rail is decreased. This is known as diminished styles or gunitec styles.
- ↳ Are used in hospitals, offices, libraries, show rooms, etc.



Partly Glazed Door

7. Flush Doors

↳ consist of a framework of rails and stiles, and it is covered with plywood or hard-board.

↳ Two types → a framed flush door
↳ a laminated flush door

↳ Framed flush door

↳ consist of stiles, rails, horizontal ribs, vertical ribs, and plywood.

↳ The hollow space is sometimes filled with granulated cork or any other light material.

↳ are light in weight and cheap, but are wear, so they have become practically obsolete.

↳ Laminated flush door

↳ consists of stiles, rails, laminated core and plywood.

↳ Laminations of wood are glued together in great pressure making them heavy but require more material for construction.

↳ Plywood sheets on either side are also glued to the laminated core under great pressure.

↳ The flush doors are prepared by specialist firm and are available in standard sizes.

↳ Thickness of plywood facing → 6mm

" " flush door → 25-40mm

Flush doors are especially used for interior works and are economical, easy to clean, better in appearance, reasonably strong, little affected by moisture, termite-proof and crack-proof.

8. Louvered Door

- ↳ Shutters are provided with louvers, either fully or partly.
- ↳ Louvers are arranged at such an inclination that horizontal vision is obstructed.

- ↳ Louvers → may be movable or fixed

- ↳ kept sloping away from inner position

↓
This arrangement will prevent the entry of moisture from the outside

- ↳ Provide free ventilation and at the same time maintain sufficient privacy of the room. However, door harbours dust easily, which is very difficult to be cleansed.

- ↳ generally used for latrines and bathrooms.

9. Collapsible Steel Door

- ↳ consist of mild steel frame

- ↳ two vertical pieces of mild steel channels, about 15-20mm wide, are joined together with the hollow portion of the channel inside. A vertical gap of about 12mm to 15mm is thus created

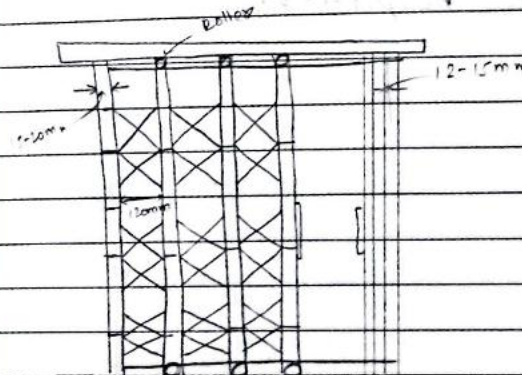
- ↳ such pieces spaced at 120mm center to center and are joined to one another by cross join pieces

- ↳ Rollers are provided at top and bottom

- ↳ provides additional safety

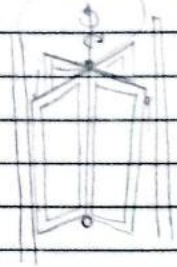
- ↳ do not give privacy inside the room

- ↳ commonly used in compound gates, residential building gates, bank locker room, school and college entrance door, etc



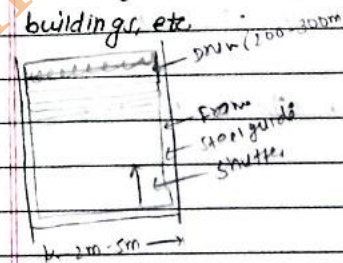
10. Revolving Door

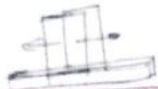
- ↳ consists of centrally located mullion or pivot to which four radiating shutters are attached.
- ↳ central pivot is supported with ball and bearing at the bottom and bush bearing at the top so that its rotation is smooth and w/o any jerk, friction and noise.
- ↳ A revolving door simultaneously provides entrance on one side and exit on other end.
- ↳ keeps the opening automatically in closed position, when not in use.
- ↳ very much useful for building where there is heavy rush of foot traffic, and for air-conditioned buildings. Hence they are provided in big hotels, banks, offices, theatres, hospitals, etc.



11. Rolling Steel Door

- A rolling steel door consists of a frame, a drum and a shutter of thin steel plates or iron sheets of thickness about 1mm.
- The width of door vary from 2m-5m and dia. of drum is about 200-300mm.
- The shutter moves on steel guides provided on sides and usually roll in turn.
- They provide security against fire and burglars.
- They are however not good in appearance and they can cause noise in movements.
- Usually used in garages, show rooms, shops, godowns, factory buildings, etc.





12 Sliding door

- In this type of door, the shutter slides on the slider with the help of runner and guide.
- The door may have one ~~side~~ sliding shutter, two shutters or even three shutters depending upon the size of the opening and the space available for sliding.
- The cavity may be provided in the wall to receive the door in an open position or it may simply lie touching the wall, the latter arrangement being very common.
- A sliding door does not cause any obstruction during movement.
- It is provided with handles, locking arrangement, stopper, etc.
- Used for entrances of godowns, sheds, showrooms, etc.



13 Swing door

- Swing door has its shutter attached to the frame by means of special hinges known as double action spring hinges and thus shutter can be moved both inward and outward.
- They may be single shuttered or double shuttered and shutter is hinged on frame.
- preferred in offices, banks, public buildings such as govt. offices, etc.

* Method of fixing a timber door:

(i) First, when the brick work is completed, measure the door opening. Generally, standard size of door is taken as 3 feet width and 7 feet height.

(ii) Manufacture timber frame of size 2 feet 4.5 inch wide and 7 feet height.

Clearance = 0.5 inch (provided b/w wall & frame)

(iii) Wooden primer is ~~applied~~ applied.

(iv) Anti-termite treatment of frame (e.g. black japor)

(v) Use support diagonals.

(vi) Clamp the frame with the hold fast (iron hold fast of greater thickness) 6 clamps in each door (3 in each side)

(vii) Frame attached 10mm out of brick face

(viii) Check verticality of frame with help of plumb bob and level with water level or spirit level.

(ix) If door is to be constructed in column, use fastener (P-10mm dia)

(x) Fill concrete in the holdfast hole and cure for 5-7 days.

~ (xi) Different door accessories are fitted

✓ Butt Hinge → To fit door with frame
(150mm from top and 150mm above bottom)

✓ Tower bolt → 800-850mm from FFL

✓ AL Drop → 800-850mm from Finished Floor Level (FFL)

✓ Door handle → 900-1000mm from FFL

~ Door frame which are likely to get contact with the masonry is painted with suitable paint for moisture and termite protection

~ In case of fixing frame as the wall is built, hold fast and horns are used to lock frame to masonry

~ In case of fixing frame later (like aluminium), wooden pegs are kept in wall flush to the surface and door frames are then screwed to it. Generally GI wood screws are used.

* WINDOWS

- ↳ A window is an opening in a wall, door, roof or vehicle that allows the exchange of light and may also allow the passage of sound and sometimes air.
- ↳ provide natural lighting, facilitates ventilation.
- ↳ Glazed panels in closed condition provide light and in open condition both light and ventilation.

• Main functions:

- providing natural sunlight
- Delivering energy efficiency
- ventilating the home
- provides outdoor view

- Selection of size, shape, number, location, etc depends on
 - size of the room
 - Location of the room
 - utility of the room
 - Direction of the room
 - Direction of wind
 - Climatic condition, humidity, temperature, etc
 - External views and scenery
 - Architectural requirements for external and internal

- Breadth of window = $\frac{1}{8}$ th of (width + height) of room.

- Area of window = opening of window be 10-20% of floor area depending on climate
- Area of window should be $1m^2$ for each $30-40m^3$ of volume of room.
- For public buildings: At least 20% of floor area.
- Glazed panels must be at least of 8-10% of floor area for lighting.

view of fixing window

Window frame is fixed on wall and wall are constructed anchoring the hold fast.

Frames are leveled and placed well

Lintel is made at top of frame as to support load distribution

If windows are fixed later then the series of screw hold the frame of the windows

Timber frames are generally constructed side by side with masonry and aluminium and UPVC are fitted later with screws

* Types of window

1. Casement window

↳ window that is attached to its frame by one or more vertical hinges at the side

→ Shutters of such windows open like a door

→ One frame, separately movable of such window is known as casement sash

→ Most commonly used.

→ Allow more ventilation and airflow in room

→ can be opened fully.

↳ Awning window: Pivoted at top, opens outwards

↳ Hopper window: Pivoted at bottom, swings inward

2. Fixed window

- shutters are fixed to the window frame
- Used for the sole purpose of admitting light

3. Glazed/sash window

- ↳ consisting glass panels.
- Fully glazed casement window.
- sashes are rebated to receive glass panels
- width and depth of rebates are 15mm and 5mm resp.
- Glass is secured in position either by putty or using small fillets called glazing beads

Glazed section :

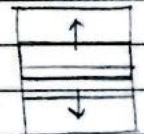
- ↳ Panel with glass
- If single layer of glass then single glazed and if 2 its double glazed.
- Double glazed are good for insulation against temperature fluctuations (thermal) and sound (acoustic)
- Generally used in colder climates for thermal insulation.

4. Metal windows

- ↳ Mild steel, aluminium or other alloys.
- ↳ Either fitted to wall directly using lugs and plugs or to wood using screws.
- ↳ Subject to contraction/expansion
- Members are thin, so greater size of opening
- Durable and stronger than wooden ones
- Subject to corrosion and damage. Aluminium frames shouldn't come in contact with fresh cement plaster. Suitable paints, coatings can be used.

(5) Double hung window

- consist of pairs of shutters which can slide vertically within the grooves provided in the frame.
- Double hung windows open from both top sash and bottom sash
- These windows can be opened to let cool air in through bottom pane and release warm air through top pane.
- Only half of the opening available for ventilation.



(6) Pivoted window

- Shutters are allowed to swing round the pivots
- May be vertically pivoted or horizontally pivoted
- can rotate 90° - 180° about a horizontal or vertical axis usually located on or near the centre of the sash.
- windows allow for full ventilation in ~~the~~ small space but cannot be equipped with a screen.
- can be circular shape too

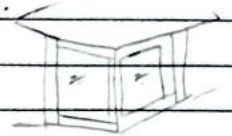
(7) Louvered windows

- Allow free passage of air when closed.
- and at the same time provide sufficient privacy
- can be fixed or adjustable type.
- Angle of inclination can vary from 0° to 90°
- Louvers should slope downward to the outside so that rain water does not get entry into the building
- Are not completely airtight.



(8) Corner windows

- provided at corner of rooms
- There is entry of light and air from two directions.
- Special lintel is casted at the corner
- Lath part of the window at the corner is made up of heavy section.
- Expensive than other type of window.
- Difficult installation
- Aesthetic appeal



(9) Gable window

- provided at the gable ends of the roof.
- Gable end window follows a roof structure
- Top floor spaces flooded with natural light.
- Proper care should be taken to prevent water entry.



40. Dormer window

- projects or juts out from a sloping roof
- Acts as a project light and air in room which are constructed below or below the roof slope
- Aesthetically value
- Expensive and difficult to install



(41) Bay window

- projects outside the external wall of a room
- May be in any shape
- Admits more light; improves ventilation
- Provides 30° outdoor view
- Extends the length of room up to 3 feet
- Difficult to install



42) Clerestory window

- provided where the roof part is raised
- glazed windows are used for this purpose
- provide ventilation to inside of room as the roof is blocked by verandah
- Improve appearance
- But heat insulator

(43) Louver window: (flat roof)

- fixed on roof for lighting the inner portion of building
- May be rectangular, square or curved
- If ventilation is also required pivoted window is used
- solar heating
- Not used in winter
- Aesthetic

(14) Skylight windows

- provided in sloping surface of the pitched roof
- common rafters are suitably trimmed and skylight is erected on a curb frame
- Mainly for light; they are provided with fixed glass panel
- Difficult to clean

(15) Aankhi Jhyot

- small wooden window used in traditional and cultural buildings of Nepal
- Ancient Architectural value
- small pane present
- Not so efficient for lighting.

* Ventilators

- windows of small heights generally fixed on top of door and windows
- narrow opening for flow of air
- Gen. placed about 30 to 50 cm below roof
- consist a frame and shutter
- provided as per by-laws of municipality

Surendra Sharma

* Mortar

- Paste made from mixture of sand or fine aggregates with a suitable binding materials and made moist with suitable amount of water.
- Clay gives mud mortar, lime → lime mortar, cement
↓
cement mortar.

- It is used to bind building blocks such as stones, bricks, and concrete masonry units together, fill and seal the irregular gaps between them.

Fine aggregate + Binding Material + Water ⇒ Mortar
(sand) (Clay, lime, cement)

• Function of Mortar:

- Binds units like bricks, stones, blocks, etc. to form a structure.
- Fill empty spaces and voids by thin mortar called grouts.
- Provide protection layers like plasters.
- Solid mass to transfer the loads uniformly like PCC in base of wall or foundation.
- Used to bind coarse aggregates to form a solid mass like concrete.
- Used for surface dressing like jointing and pointing, plastering, etc.

* Types of Mortar

- Cement mortar
- Lime mortar
- Lime-cement mortar
- Special mortar

(1) Cement mortar

- Mortar containing cement as binding material.
- Sand or fine aggregate in different ratio with cement and mixed and formed paste with fixed ratio of water (Cem. to sand. 1:3 to 1:6 or more) ✓
- One of the strongest type of mortar so often used in wide variety of constructions consisting heavy loads. (load bearing walls, pillars, columns, etc.)
- Low cement ratio → weak joints and porous layers.
- Used for weather resistance and water proof layer (plaster).

• Preparation

(i) Hand mixing (Manual labor)

- small quantity
- First dry mix of binder and aggregates.
- Made a depression and required water is poured.
- Slowly placing dry mixture on edge till water is absorbed by mixture.
- Mix thoroughly the mortar till uniform paste is obtained.
- Should finish using before initial setting of the cement.

(ii) Machine mixing

- Large quantities
- Use mechanical mixtures: mixing drills or drum mixtures
- All ingredients in mixer in same time

• Use of cement mortar

- Where high strength is required like pier, dam, foundations, etc
- Plastering and pointing
- Damp Proof Course (DPC) below ground level and weather-proofing
- Mixed with coarse aggregates and boulders to create a solid mass of good strength like concrete.

(2) Lime-Mortar

- Binder is fat lime or hydraulic lime
- Volume change during setting of lime is 2-3 times sand is mixed to ~~minimize~~ minimize
- Binder with sand stronger than to lime itself

→ Fat-lime mortar:

- should be slaked before use
- cannot be used where water contact is there
- used for building work internally and externally.

→ Hydraulic-lime mortar:

- can be used in water contact area
- stronger than fat-lime mortar
- use within one hour of mixing
- General ratio is 1:2

- Prepared by mixing lime mortar with cement in suitable proportion
- Hydraulic and semi-hydraulic limer (Class A, B & C of IS code) suitable for masonry mortar.
- Fat lime (Class C & D) needs mixing of burnt clay pozzolona and other pozzolonic materials to control its cons
- Limer can also be used with cement binder to enhance its properties.

• Preparation:

→ Manual mixing or pounding:

- ↳ Dry mixed in water tight platform or pucca tank
- ↳ Right amount of water is added and mixed manually till fine consistency
- ↳ Use for small quantities only

→ Mortar mill mixing or grinding:

- ↳ Dry mixed and fed to a mortar mill
- ↳ Water is added and grinded
- Unslaked large particles get grinded and uniform consistency is obtained

→ Bullock-driven grind mill:

- circular trench with 5-8m dia, 40cm depth and width as per thickness of grinding wheel.
- wheel attached to shaft to a bullock and rotated pivoting at center
- wheel run in trench grinding and mixing mortar

→ Power-driven grind mill:

- Uses power motor to rotate the shaft and roll the wheel and grind the mortar

(3) Lime-Cement Mortar.

- called gauging mortar
- Suitable amt. of cement is mixed with lime mortar and process is called gauging
- It improves the hydraulicity, strength, economy and density of the mortar.
- Non-hydraulic, semi-hydraulic and hydraulic lime can be used
- Cement:lime:sand = 1:1:6, 1:2:9, 1:3:12
- More plastic and workable
- should be used before cement starts to set.

• Uses:

- Bedding or thick brick wall
- Can be used for cavity walls to bind stones, bricks, blocks, etc.
- Gives thin joint ~~than~~ than other lime mortar so economic
- Plastering and weather proof pointing

* Special Mortars:

(i) Mud Mortars

- Sticky clay is mixed with water till it acquires required consistency
- Cheap and locally available
- Certain fibrous material added to prevent shrinkage & crack.
- Life is generally 5-15 years and depends on water proofing and other factors like insects, plants, etc.

• Use:

- Low strength brick work
- Surfacing floors and walls can be done with water and weathering protection using paints, etc.

(ii) Cement-Clay Mortar

- Finely ground clay and cement are mixed with 1:1 proportion
- Improves the water retaining ability, grain composition and workability with density of mortar.

• Uses:

- Masonry joints
- Plastering

(iii) Light and heavy weight mortars

• Light weight mortar

- obtained by adding materials such as asbestos fibres, wood powder, saw dust, etc to ordinary cement or lime mortars
- Use light porous sand from pumice or other fine light aggregates
- Used in heat proof and sound proof structures, where load acting is low (partition walls, decorative walls, etc)

• Heavy weight mortar

- heavy aggregates like quartz, minerals, etc are used
- Metals or alloys can also be used in mix to increase density (lead, iron, etc)

Use:

- Use in places where load may be high
- Require higher density for stability like in dams and foundation or anchorage
- Protection against radiations

(iv) Decorative Mortar

- uses color pigments, additives and fine aggregate in suitable proportion.
- Aggregate and its size depends on color and texture of the work required
- give pleasant & Aesthetic appearance to outer walls.

(v) Air entrained (plasticized) Mortar

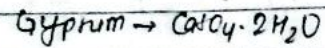
- Air as plasticizer is used to make mortar workable and to improve flow capacity
- Entrained air makes the mortar light and provides better heat and sound insulation.
- Increases durability for freeze and thaw action

• Use

- Durability is required
- Surface exposed to freeze and thaw
- where light weight is required.
- Insulation for sound.

(vi) Gypsum mortar

- Gypsum as binding material, which hardens when moistened and allowed to dry
- called plaster of paris
- Not durable in damp condition



Use:

- Quick setting so used in sticking decorative in walls and ceilings.
- Used for joining & pointing work
- Also used in medical sector as cast

(vii) Packing Mortar

- has water resistance, high homogeneity, resistance to sub-soil water pressure, form solid water proof in cracks, voids, etc.
- generally cement-sand, cement-loam or cement-sand loam.

• Use

- Ground & wall for avoiding water rise

(viii) Fire resistance mortar

- created by blending aluminous cement with finely powdered fire bricks.
- Act as fire proof shield

• Use

- Furnace, fire places, etc
- Risk of fire is high

(ix) Sound absorbing mortar

- Binding material as cement, lime, slag, etc with light and porous materials like pumice, saw dust, cinder, etc
- Sound absorbing property in plaster and casted wall and floor.
- Mitigate noise levels

• Use

- Auditorium, hall, theatres, etc

(v) X-ray shielding Mortar

- heavy mortar with density $> 2000 \text{ kg/m}^3$
- Incorporates fine aggregate from dense rock and appropriate admixtures.

• Use:

- Plaster walls and ceiling of X-ray cabinet to protect room against ill effects of X-rays

• Properties of good mortar

- Mortar should possess adhesion. Good mortar should provide good adhesion to building units (bricks, stones, etc.)
- It should have the capability of resisting the penetration of water.
- Should be easily workable in the site condition.
- It should be able to withstand against tensile & compressive stresses.
- Cheap
- Durable

Modular brick: $80 \text{ cm} \times 20 \text{ cm} \times 10 \text{ cm}$

• Brickwork → Use of mortar and brick units to construct a structure

↳ strength depends on strength of brick and constituent & application of mortar used.

• Principles to be observed in masonry construction

- Brick should be sound and hard, well burnt, uniform shape and sizes, etc.
- Brick should be thoroughly soaked so as water penetrates through full depth as to avoid water absorption from mortar later.
- Should be laid on full layer of mortar and slightly pressed as to uniformly distribute the mortar over brick area.
- Must be laid true horizontally and vertically (no inclination and wobble)
- Joints must be flushed and filled with mortar as to leave no cavity in joints.
- Progression should be in side by side for inter connected bricks and must not be greater than 100 cm for a course in a day.
- All joints should be filled upto a depth of 10-15 mm with mortar for proper key for plastering or pointing.
- Joints must not run throughout the height in a vertical line.
- Fixtures like pipe, brackets, hold fast of doors and windows, etc. as to be fixed in the brick ~~work~~ should be embedded in cement mortar or in cement concrete.
- Should wait for 28 days for plastering for avoiding shrinkage problems from mortar and concrete in masonry.

- All the masonry work should be cured for 7 days and a particular surface can be covered with jute and kept in moist condition.
- For future expansion in length, brick wall is ended with a toothed end or a step for continuous bonding for new and old walls.
- For temperature movement 20mm joints are provided for every 3m length of wall.
- Suitable scaffolding should be used to carry out masonry work at higher levels.

* Estimation of Brick work

1. Calculate the vol^e of brick work (walls, foundation, etc)
 2. Find the size of unit brick with mortar attached (3 sides)
 3. Calculate the volume of brick + mortar and number of brick + mortar required from total volume of work
 4. Number gives the no. of bricks + mortar & also bricks
 5. Calculate volume of mortar required (from volume of single ("brick + mortar" - "brick") and using numbers of brick + mortar
 6. Calculate dry volume of mortar (33% increase due to wet shrink in volume)
 7. Calculate volume of cement & its wt. using cement sand ratio (1:4:6 by vol)
 8. Calculate volume of sand using cm. sand ratio.
- u. Similarly it can be done for the 20m² of the brick work for 9cm thick walls (mortar only in 2 surfaces of each brick)

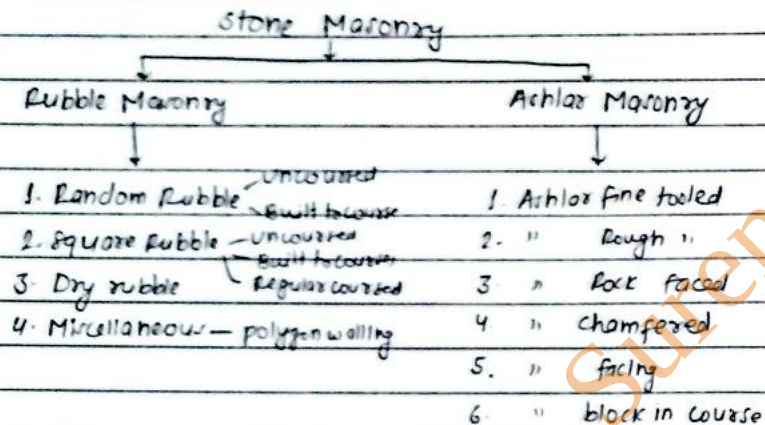
* Brick Bonding

* Stone Masonry

- Any wall or structural members using stone as the basic unit
- Stone used should be hard, tough, durable, free from cracks, cavities

Advantages:

- Helps to maintain the thermal comfort
- Reduces the cost of painting
- Good fire protection and long-life span
- Attractive appearances



1. Rubble Masonry

(i) Uncovered

- block stones are rough and irregular
- Rugged and cheapest
- stones are laid w/o forming the courses
- stones vary size very much
- To avoid thick joints, chips & spalls are used
- For construction of wall of low height

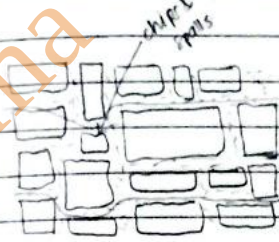


Fig. Uncovered Random Rubble

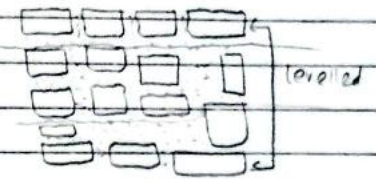


Fig. Built to courses (Random Rubble)

(ii) Built to course

- Roughly levelled
- courses vary in 30-45cm thick
- Boundary wall, residential building, abutment of ordinary bridges

2. Square Rubble

(i) Uncoursed

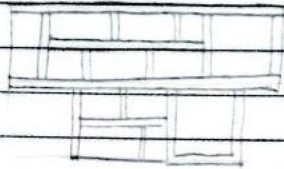
- Having more or less straight beds & sides
- Brought to shape by hammering to straight cut finish
- Risen (larger stones)
- Leveler (thinner stones)
- Sneak or check (smaller stones)



(Uncoursed square Rubble)

(ii) Built to course

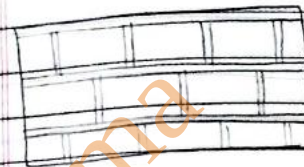
- leveled to courses at varying depth.
- used same stones used for uncoursed square Rubble.



Square Rubble
(Built to course)

(iii) Regular courses

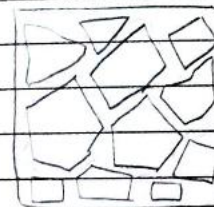
- consist of various courses of varying heights
- Height in particular course is same.



(Coursed)

3. Polygon walling (Polygon rubble masonry)

- Hammer finished to irregular polygon shaped face.
- Arranged in such a way that it avoids the vertical joints.
- Break joints as much as possible.



4. Dry Rubble masonry

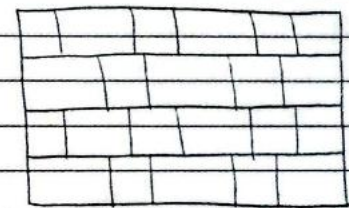
- Similar to ordinary rubble masonry but using mortar
- Small spaces are filled with smaller stones
- Used in non-load bearing walls
- Garden walls, compound walls

* Ashlar masonry

- Finely dressed stones in square or rectangular shape are laid in cement or lime mortar.
- Each course is of uniform height (25-30cm), all the joints are regular, thin and have uniform thickness.
- The stone gives perfectly horizontal and vertical joints with adjoining stone
- Costly due to fine dressing of stone

1. Fine toolled Ashlar Masonry

- exposed face is finely chiselled or dressed to give it a smooth texture
- All the courses are kept in same height
- Cut to fixed cubical shape blocks.



(Fine toolled)

1. Ashlar rough hauled

- The exposed face is dressed by rough haling to give it a rough look

2. Look or Quarry faced Ashlar Masonry

- The exposed face of the stone is not dressed and kept as it arrived

3. Ashlar chamfered

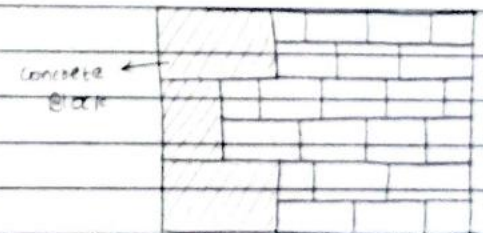
- similar to quarry faced except that the edges are beveled or chamfered to 45° for depth of 2.5 cm or more
- used in kitchen, bathroom
- Grout is filled between adjacent blocks of stones



(Ashlar chamfered)

4. Ashlar facing

- Ashlar is used only in face for looks
- It is very expensive, so not commonly used throughout the whole thickness of the wall, except in works of great importance and strength
- For economy, facing are built in ashlar and the rest in rubble



(Ashlar facing)

6 Ashlar block in course

- Fine dressed blocks are laid in course
- Intermediate b/w rubble & ashlar masonry
- The faces of each stone are hammered, dressed & ht. of block is kept the same in any course.
- Depth of course may vary from 15-30cm
- Adopted in heavy works such as retaining walls, bridge, etc.

* Retaining walls

- walls to retain water pressure, earth pressure, sand, etc
- Used in hills, roads, dams, etc
- Different designed as per site conditions
- May be dry masonry, stone masonry, brick masonry, RCC, etc

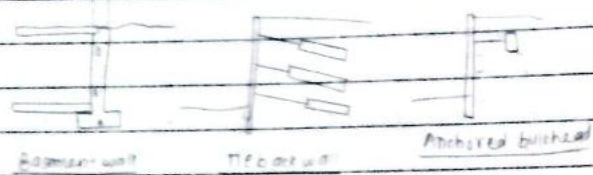
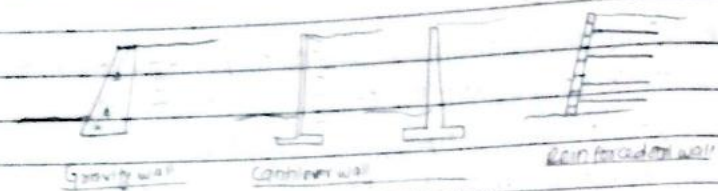
• Why Retaining walls are needed in Building

- ✓ Slope stabilization
- ✓ Land utilization
- ✓ Property Boundary Definition
- ✓ Flood prevention
- ✓ Mitigating Impact of Excavation

• Features:

- Depth of fill increases because for thickness of wall increases per depth
- Esent may be inclined or vertical but back is stepped
- Thickness is generally kept $0.33h - 0.4h$ of fill and varies in material used to fill and material of wall
- Sufficient no. of weep holes are to be provided for draining water from fill

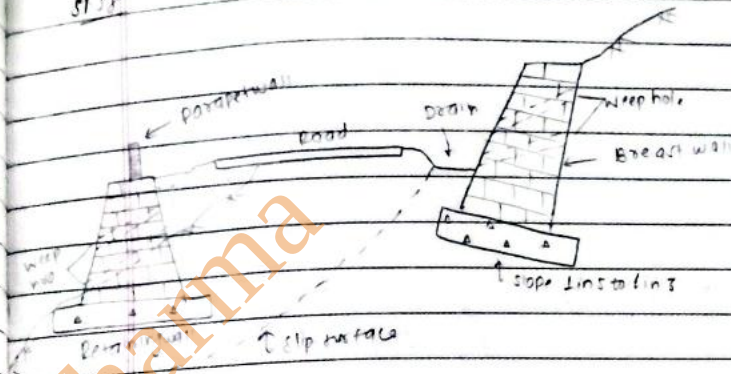
PMIS 57



* Breast wall

→ Similar to retaining walls but is constructed to protect natural sloping ground from weathering and small post in stabilization

SI 58



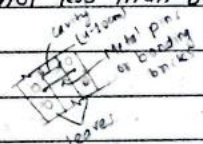
* Cavity wall (or hollow wall)

→ consists of two separate walls, called leaves or skins, with a cavity gap in between.

→ The leaves may be of equal or different thickness (load bearing or not)

→ Two portions of the wall may be connected together by metal ^{pins} or bonding bricks at suitable intervals.

→ Size of cavity is 4-10cm and leaves not less than one width of brick (10cm)



• Advantages of cavity wall

↳ Insulation and Thermal Efficiency

↳ cavity wall creates an air gap that acts as a thermal barrier, reducing heat transfer and enhancing energy efficiency.

↳ Moisture control

↳ cavity facilitates drainage and ventilation, preventing moisture buildup and safeguarding against dampness and mold.

↳ Sound Insulation

↳ Air gap → natural sound buffer
(quieter indoor environment)

↳ Structural stability and Durability

↳ cavity wall enhances load distribution, minimizing the risk of damage, ensuring long-term structural resilience.

• Disadvantages

→ construction difficult than ordinary wall.

→ High skill manpower is required.

→ There is high risk ^{that} ~~of~~ moisture can penetrate from the external leaf of wall to the internal or cavities were not really designed to be filled with materials.

→ Might leave unfilled air pockets causing 'cold spots' on the inside wall.

→ Possibility of rusting of wall ties.

★ Parapet wall

→ a low wall projecting above the level of a roof, bridge or balcony forming a guard or barrier at the edge.

→ Acc to NBC-206-2003, all accessible roof terraces and balconies shall have parapet walls and handrails that are not less than 1m in height.

→ Good practice to provide weathered coping in one or both directions.

→ A full DPC should be bedded in mortar to prevent water penetrating the coping through the coping joints.

• Purpose of Parapet wall

1. Safety

2. Privacy

3. Appearance

(As discussed : 57 →)

42

Flooring



- In order to sub-divide the portion between plinth level or basement level and roof level, the solid constructions are carried out. These constructions are known as the floors and the exposed top surfaces of floors are termed as flooring.
- Bottom surface of room or space.
- Makes more accommodation space.
- In modern buildings the subfloor often has electrical wiring, plumbing and other services built in. As floors must meet many needs, some essential to safety, floors are built to strict building codes in some regions.
- Floor supports live and dead loads of the room.
- Transfers load to beams or load bearing walls.

* Requirements of good floor finish

1. Adequate strength and stability
2. Adequate fire resistance
3. Sound insulation
4. Damp resistance
5. Thermal insulation
6. Easy to clean
7. Serviceability.
8. Economical.

* Purpose of Flooring

- (i) Provide level surface with sufficient strength.
- (ii) Supporting the occupants of building.
- (iii) Provide resistance to heat loss through floor.
- (iv) To provide comfort, durability, safety and decoration.
- (v) Exclude passage of water and water vapour.

* Components of Floorings:-

1. Subfloor base course or floor base:

- ↳ provides proper support to the floor covering and the superimposed loads carried on it.
- ↳ Floor may be built on beams or joists or use structures like prefabricated or cast slabs. The subfloor builds on these and attaches by various means particular to the support structure but the support and subfloor together always provide the strength of a floor.
- ↳ The subfloor may also be provided with forced air ducts for both heating and air conditioning, or pipe holes for heat exchangers (radiators) and the cables and wirings can be run through it to conceal it.
- ↳ In ground floor or basement, floor rest on the compacted ground so moisture movement must be considered and countered.

(2) Floor covering or flooring:

- ↳ provides a smooth, clean, impervious and durable surface.
- ↳ any finish material applied over a floor structure to provide a walking surface.
- ↳ Materials almost always classified as floor covering include carpets, area rugs, and resilient flooring, such as linoleum or vinyl flooring.
- ↳ Materials commonly called flooring include wood flooring, laminated wood, ceramic tile, stone, terrazzo, mortar and various seamless chemical floor coatings.
- ↳ Choice of material for floor covering is affected by factors such as cost, endurance, noise insulation, comfort and cleaning efforts.
- ↳ Some types of flooring must not be installed below grade (lower than ground level), and laminate or hardwood should be avoided where there may be moisture and condensation.

* Material for construction:-

- (i) Cement concrete
- (ii) Lime concrete
- (iii) Stones
- (iv) Bricks
- (v) Wooden blocks for wood.

Ground floor

(1) Solid ground floors

- ↳ Solid ground floors are a type of flooring construction that directly rest on the ground or a compacted sub-base.
- ↳ commonly found in residential, commercial, and industrial buildings.
- ↳ involve several layers to provide stability, insulation, and support.

Layers of solid ground floors:-

1. Subgrade
2. Damp proof Membrane
3. Concrete slab
4. Screed layer
5. Final floor finish

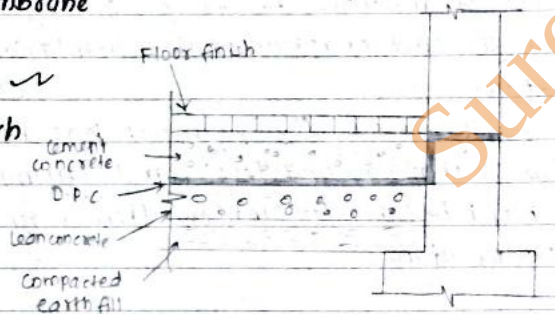


Fig.

(a) Subgrade:-

- ↳ serves as the natural ground or a prepared sub-base on which the solid ground floor is constructed.
- ↳ provides the foundational support for the entire structure.

(b) Damp proof Membrane (DPM):-

- ↳ crucial layer laid over the subgrade to prevent moisture from rising into the floor structure.
- ↳ acts as a barrier, protecting the floor from potential damage caused by ground moisture.

(c) Concrete slab:-

- ↳ primary structural element of the solid ground floor.
- ↳ typically, made of reinforced concrete, its thickness is determined by the intended use and the load it needs to support.
- ↳ provides strength and stability to the floor.

(d) Screed layer:-

- ↳ a thin mixture of sand and cement or other leveling materials applied over the concrete slab.
- ↳ It serves to create a smooth and level surface for the final floor finish, ensuring a proper foundation for walking or placing furniture.

(e) Final floor finish

- ↳ topmost layer of the solid ground floor.
- ↳ composed of various materials such as tiles, hardwood, laminate, carpet or other flooring options.
- ↳ choice of finish depends on aesthetic preferences, functionality and intended use of space.

Advantages

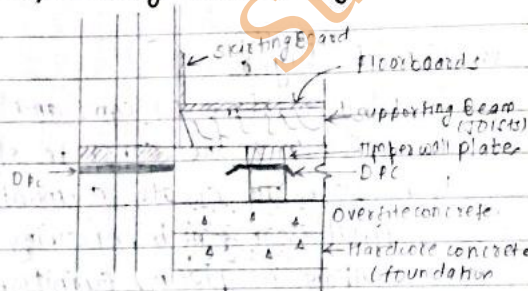
- ↳ Provides good thermal insulation & stability
 - ↳ Durable & can handle heavy loads.
 - ↳ Cost effective.
- ✓ Ideal for ground-level floors

(ii) Suspended ground floor

- ↳ type of flooring construction where the floor structure is raised above the ground level, creating a space or void beneath. This design is commonly used in buildings to accommodate services such as plumbing and wiring.

Layers :-

- (1) Sub-structure (foundations)
- (2) Damp Proof Course (DPC)
- (3) Bearers
- (4) Joists
- (5) Floorboards or decking.



(a) Substructure (Foundations):

- ↳ include the foundations or footings that support the entire building. These elements are crucial for distributing the loads of the structure evenly and ensuring stability.

(b) Damp Proof Course (DPC):

- ↳ vital layer of material, often a waterproof membrane, installed above the substructure.
- ↳ Its primary function is to prevent rising damp, protecting the suspended floor from moisture that might otherwise compromise its integrity.

(c) Bearers:

- ↳ HZ. elements that rest on the substructure and run perpendicular to the joists. They play a crucial role in distributing the load of the floor and any applied loads to the foundation, ensuring even weight distribution.

(d) Joists:

- ↳ parallel elements supported by the bearers, forming the primary hz. structure of the floor. They provide support for the floorboards, floorboards or decking above and help distribute loads evenly.

(c) Floorboards or Decking

- ↳ are visible and walkable surfaces of the suspended ground floor.
- ↳ Floorboards or decking materials, such as wood, particleboard, or engineered flooring, are laid on top of the joists providing the finished floor surface.

Advantages

- Prevents dampness and moisture problems by elevating the floor.
 - Allow easy access to under floor services such as plumbing and wiring.
 - Better insulation.
- ✓ used in areas with expansive clay soils, high water table, or ground prone to settlement.

Special type of floor finishing

[On the basis of material used for flooring].

(1) Mud flooring:

- Only used in low cost housing especially in rural areas.
- 25cm thick selected moist earth is spread and is tamped to wells to get a compacted thickness of 15cm.
- To prevent cracks due to drying, small quantity of chopped straw is mixed in moist earth.
- Sometimes cow dung is mixed with moist earth and thin patina of cement-cow dung (1:2 to 1:3 is also applied).

Advantages:

- ↳ Such flooring is cheap, hard, fairly impervious, easy to construct and easy to maintain.
- ↳ It has good thermal insulation property due to which it remains cool in summer and fairly warm in winter.
- ↳ Materials for mud flooring are easy available.

Disadvantages:

- ↳ It can easily absorb moisture from the environment.
- ↳ It needs proper and frequent maintenance.
- ↳ It is less water resistant.

* Muzam:-

- ↳ disintegrated rock with binding materials, just like mud flooring. 15cm thick muzam is laid over as subbase and 2.5cm thick fine powdered muzam is laid with water and compacted and saturate the surface with 6mm thin film water.
- ↳ After a day hard surface is formed and cow dung is painted and rammed soak for 2 days during morning hours.

• Advantages of Muzam flooring:-

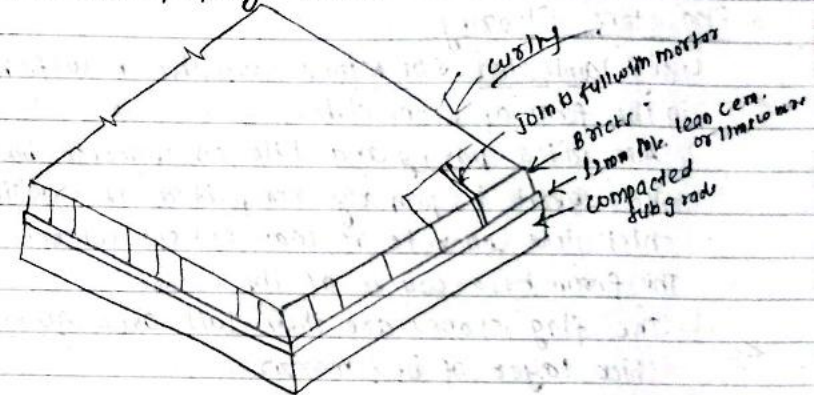
- Muzam flooring are cheap and the method of construction is easy.
- It has a long life if well-maintained.
- Gives comfort in all seasons.

• Disadvantages:-

- Frequent maintenance is required.
- This floor is less impermeable.

* Brick flooring:-

- ↳ Is a type of flooring that uses brick tiles which are made of baked clay.
- ↳ commonly used in warehouse and factories.
- ↳ At first subgrade is compacted well, over this 10 to 15cm thick lean cement concrete (1:2:16) or lime concrete is laid.
- ↳ Bricks are laid on edge (or flat) on 12mm thick bed of mortar.
- ↳ All the joints of bricks are full with mortar and finished.
- ↳ The work is then properly cured.



• Advantages:-

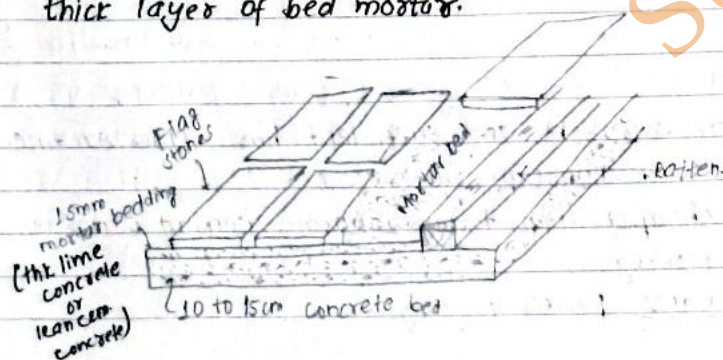
- It offers a durable and sufficient hard floor surface.
- It provides a non-slippery surface.
- It is cheaper than terrazzo, mosaic, cement concrete and marble flooring.
- Maintenance process is easy.

• Disadvantages:-

- It is absorbent.
- It is costly than mud and musam flooring.

* Flag stone Flooring

- ↳ Any laminated sandstone available in uniform thickness in the form of stone slabs.
- ↳ Also called paving and laid on concrete base.
- ↳ The subsoil is properly compacted, over which 10 to 15 cm thick lime concrete or lean cement concrete is laid. This forms base course of the floor.
- ↳ The flag stones are then laid over 20 to 25 mm thick layer of bed mortar.



• Advantages

- Very Economical for the place where stone is easily available.
- Maintenance is easy and cheap.
- It is hard, durable and wear-resistant.

• Disadvantages

- Not a very fine and smooth type of floor.
- Not very impervious as water can percolate through damage portions.

* Cement concrete Flooring:-

- ↳ most common type of flooring
- ↳ used in both residential as well as public buildings.

• consists two components:

(i) Base concrete

- ↳ Base course may be 7.5 to 10 cm thick either in plain cement concrete (1:3:6 to 1:5:10) or lime sand (or 1 lime: 1 surkhi: 1 sand) and 60% coarse aggregate of 40 mm nominal size.

pcc (1:3:6 to 1:5:10) or lime sand (1 lime: 1 surkhi: 1 sand)

- (ii) Topping or wearing surface
- After hardened base concrete, surface is brushed and cleaned thoroughly and wetted the previous night and topping is then laid in square or rectangular panels by use of glass or plain asbestos strips or wooden battens set.
 - The topping consists of 1:2:4 cement concrete and laid to desired thickness.

• Advantages

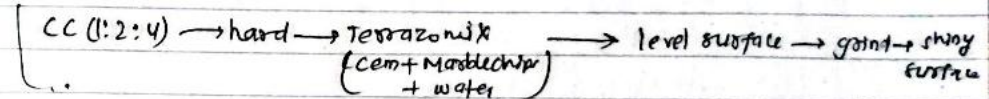
- It is durable and hence it is commonly used in kitchens, bathrooms, schools, hospitals, drawing rooms, etc.
- It is economical and also smooth and pleasing in appearance.
- It possesses good wearing properties and can be easily cleaned.

• Disadvantages:-

- (i) It requires proper attention while laying as defects in carelessly made floor cannot be rectified easily.
- (ii) If liquid does manage to make its way into the pores and cracks of a concrete floor, it can sit there and lead to the growth of mold or mildew.

* Terrazzo Flooring

- It is a composite material made up of cement and marble chips (3mm to 6mm size) in the proportion 1:1.25 to 1:2.
- Widely used in residential buildings, hospitals, offices, schools and other public.
- It is then mixed and poured in-situ onto a concrete base.
- concrete of grade 1:2:4 is then laid in alternate panels levelled and finished to rough surface.
- When the surface is hardened, the terrazzo mix (cement, marble chips & water) is laid and finished to the level surface.
- The chips are exposed by grinding. The surface is then cleaned and wax polish is applied to get final shiny surface.
- It can also be premade and available in slabs or tiles.



• Advantages of Terrazzo Flooring:-

- Better color consistency and performance.
- Excellent chemical resistance and the lowest maintenance cost of any hard surface flooring.
- Very useful in commercial situations as it is very durable and easy to clean.

• Disadvantages:-

- The surface of the terrazzo floor can get very slippery and hence is unsafe for children and the elderly.
- The surface does not retain heat well during the winter months, making the floor feeling a tad cold.
- The installation is to be made only by experienced professionals.

* Mosaic Flooring:

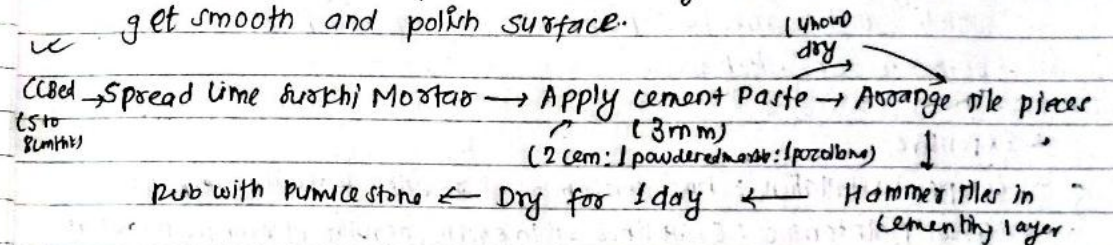
- It is made of small pieces of broken tiles of china glazed or of cement, or of marble, arranged in different pattern and these pieces are cut to desired shapes and sizes.

- On a concrete base 5 to 8 cm thick lime surkhi mortar is spread and level.

- Then 3 mm thick cementing material in the form of paste of two parts of cement, one part of powdered marble and one part of pozzolana materials spread and left to dry for about 4 hours.

- Then small pieces of broken tiles or marble pieces of different colors are arranged in definite patterns and hammered into cementing layer so that cementing material comes up through the joints, and an even surface is obtained.

- The surface is allowed to dry for 1 day, and is then rubbed with a pumice stone fitted with a long wooden handle, to get smooth and polish surface.



• Advantages

- Mosaic flooring is available in a wide variety of colors, textures, and patterns which can add a unique and artistic touch to any space.
- Made from materials such as ceramic, glass, or stone, which are durable and long-lasting.
- Mosaic flooring is useful for a place where extra cleanliness is essential.

- u Customizable
- u Aesthetic appeal
- u Durability
- u Low Maintenance
- u Versatility

• Disadvantages:

- More expensive than other types of flooring, particularly if custom designs or high-end materials are used.
- Requires a skilled professional for installation.
- Some types of mosaic tiles can be slippery when wet, which can be a safety hazard in areas such as bathrooms or kitchens.

u Expensive

- u Complex installation: time-consuming & require professional expertise
- u Grout Maintenance: Grout lines stain easily, regular cleaning & sealing reqd.
- u Hard surface: hard and uncomfortable to stand on long periods w/o cushioning
- u Slippery when wet

* Tiles flooring

- ↳ constructed from square, hexagonal or other shapes, made of clay, cement or terrazzo.
- ↳ commonly used in residential buildings, hospitals, schools, as an alternative to terrazzo flooring where floors are to laid quickly.

• Construction methods

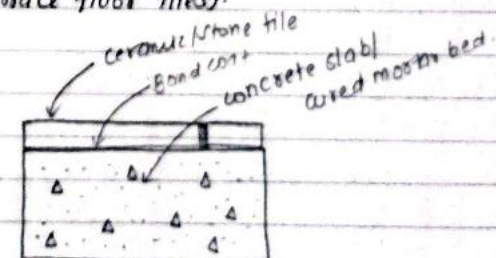
- similar to flagstone flooring except of the more care is required:

Step 1 - Surface preparation

Surface should be well compacted and cured sufficiently to gain considerable strength to offer support. No pockets of loose soil should be left.

Step 2 - Preparation of subgrade

Concrete subgrade should be free from any loose particle and foreign materials. The surface should be in SSD (Saturated Surface Dry) by means of water. Level pads (dhumru) for finished floor should be marked, and uniformly spread, considering required slope (in case of bathroom/terrace floor tiles).



Step 3 - Laying of tiles on the surfaces

1. Mortar bedding of 30-40mm is prepared with ratio of 1:8 (cement: sand) lean mixture. Avoid rich mix proportions.
2. Cement slurry should be spread on the surface at 3kg/sq.m approximately.
3. Using reference lines, tiles are placed in line, level & checked and right angle is maintained throughout.
4. Use dot pointer to check the tilting accuracy.
5. Tiles near wall are supposed to be placed 12mm away from wall for skirting.
6. After laying tile, it should be levelled by light tamping with wooden mallet.
7. Spacers should be used to maintain the alignment of tiles.
8. Spacers are provided for removal of air below tiles or extra cement.
9. Surface is now kept for drying.

Step 4 - Post tiling work

When the floor dries, floor should be cleaned thoroughly. After curing ~~the~~ for three days (avoid unnecessary foot movements) cover the tile flooring with bubble sheet / POP sheet to avoid any scratches. As we approach possession of unit grout of shade matching to the tile or white cement is filled the tile joints.
Washing and cleaning of finished floor after completely drying.

• Advantages of tile flooring.

- Durability
- Water resistance
- Easy maintenance
- variety and aesthetic beauty
- Allergy friendly: less prone to dirt-mites, pet dander or pollens, etc.
- Resistance to fire and fading
- Cost-effective in the long run: due to durability & easy maintenance.

• Disadvantages:

(i) Coldness:

↳ feel cold, especially in cooler climates.
↳ do not retain heat well, which can make them uncomfortable for walking barefoot, particularly in the winter.

(ii) Hardness:

↳ tiles can be tough on the joints and back, especially if you stand or walk on it for extended periods.

(iii) Susceptibility to cracks:

While durable, tiles can crack or chip, especially if a heavy object is dropped on them. The grout lines are also prone to cracking or staining over time, and these issues may require repair.

(iv) Grout maintenance:

(v) Echo and noise:

often noticeable in bathroom tiles.

(vi) Slippery surface

* Marble flooring

→ Superior type of flooring used in bathroom and kitchen of residential buildings where cleanliness is an essential requirement.

• Construction methods:

Step 1 - Measure twice

↳ Measure the dimensions of the area you wish to tile, and then figure the square feet of the area. Order an additional 5% to 10% of the tile to allow for cutting and waste.

Step 2 - Clean surface thoroughly & prep.

Whether applying marble tiles to floor or walls, it is imperative that you start with a clean, dry surface. For flooring, when installing on a concrete slab, clean the area thoroughly with a wet sponge to remove any stubborn dirt or grime. For installation over wood sub-floors, make sure area is free from dirt and grime.

• Install

Step 1 - Measure and find center

↳ You want the marble tiles that you install to radiate outwards from the center of the room, rather than starting abruptly from one of the walls. In order to achieve this effect you need to draw a reference line on the surface of underlayment. Find the center of two opposing walls and use a line chalk to draw a path in between them. Then measure to the center of that line, and use a T-square to make an intersecting chalk path to the other two opposite walls.

Step 2: Preview tiles in place and set permanently. After determining the center of the room with the reference lines, you can begin to experiment with a layout design.

Starting at the center of the room and working your way outward, lay down one row of tile along the reference line. Blend and adjust the tile placement until you achieve an optimal look.

- Once you have decided on the tile layout, mix the adhesive, also called mortar or thin-set, that is recommended for your tile. Follow the manufacturer's directions for preparing the adhesive.
- Using a notched trowel, apply thin-set to a small area on the floor for installation. Use the notched edge of the trowel to create grooves in the thin-set. Creating grooves will increase the strength of the adhesive.
- To continue the installation process spread the thin-set on one tile and place it where desired. Repeat this process, working with one tile at a time, until you reach the wall. To keep the placement straight, use the reference lines as a guide. Also, use tile spacers to keep the layout consistent, as well as create uniform grout lines.
- Once you reach the wall, take note of any odd angles or gaps that require custom cut pieces.
- Continue the tile installation by returning to the center point and laying out the second row of the tile adjacent to the first.

Step 3: Measure twice, cut once.

In most marble flooring installations, you will need custom cut pieces in order to stretch the floor out to meet the walls. You will also need to fit tiles around architectural features in the room, as well as permanent appliances and equipment.

The way to do this is with the use of a wet saw. Carefully measure and make a straight line with a pencil on marble tiles prior to cutting.

If a wet saw is unable to make a specific cut, use a 4-inch grinder to cut curves, cutouts, or hard-to-reach angles. Wipe any moisture from the tiles and install.

Step 4: Wait 24 hours before proceeding to step 5.

Step 5: - Mix & apply Grout

Mix grout according to manufacturer's directions. Never use sanded grout for marble tile surfaces as sanded gravel can leave scratches and swirls. Mix slowly until you reach a creamy consistency. Apply the grout to the grout joint only. Avoid sneaking grout over the entire surface of the tile. Allow to dry the recommended period (often not too long) before wiping grout off the surface. Do not wait too long. If the grout dries too much, it will make cleanup much more difficult.

Fill a bucket with warm and dampen a sponge to clean the excess grout away from the grout lines. Do not gouge or wash out the grout. Clean the entire surface with water.

repeating as necessary, to remove all grout from the tops of the tiles

Step 6 - wait 24 hours to apply sealer.

After you've allowed your grout to dry for 24 hours, make sure the surface is clean, and free of dirt. Apply a tile sealer, made specifically for marble, according to manufacturer's instructions.

Apply as many coats as it takes until the marble tile and the grout stop absorbing the sealer.

* Advantages

- Durability
- Water resistance
- Easy maintenance and cleaning process
- Cool temperature.
- Hypoallergenic
- Variety and aesthetic beauty.
- Resistance to fire and fading.
- Cost-effective in the long run: Due to durability and easy maintenance.

* Disadvantages

- Susceptible to cracks
- Risk of acid: Toilet cleaners contain acid. content than not used in bathrooms.
- Prone to cracking
- Coldness
- Hardness
- Installation complexity than tile flooring.

* Granite flooring

- ↳ incredibly hard, one of the hardest natural stones meaning that it will stand up excellently to things like pet claws or heavy foot traffic without so much as a scratch.
- When properly sealed, granite is very resistant to moisture and can be used with little worry in kitchens or bathrooms. It is also resistant to stains, like those from acidic foods, which is what makes it so ideal as a material for countertops.
- Granite's natural beauty is one of the main reasons that people choose it as a flooring material.
- Granite is very low maintenance. Simple sweeping and occasional mopping should be sufficient to keep your floors looking gorgeous.
- Granite flooring is well-suited for radiant, in-floor heating.

Granite vs Marble

• Durability:

Granite: Extremely durable, resistant to scratches, stains, and heat. Ideal for high-traffic areas.

Marble: Softer, and more prone to scratches, stains, and etching, especially from acidic substances. Requires more care.

• Maintenance:

Granite: Low-maintenance once sealed; needs periodic sealing to protect against moisture and stains.

Marble: Higher maintenance, needs frequent sealing and is more vulnerable to staining and damage from chemicals or acidic spills.

* construction methods

- ↳ clean and dry the sub-floor dry before installing.
- ↳ Lay out floor tiles and use plastic spacers to keep the granite tiles properly aligned. Trim the tiles using a wet saw, so as to fit.
- ↳ Now, mix the thin-set as per the instructions on the pack.
- ↳ place the backer-board and screw it down. This makes the surface smooth and which protect granite from damages.
- ↳ Hold the trowel at 45 degrees angle to form consistent ridges.
- ↳ Use a slight twisting motion to press the granite tile into the mortar, by tapping it down with a rubber mallet. This ensures force out air pockets to complete contact.
- ↳ Allow the mortar to dry for 24 hours.
- ↳ In small batches mix grout. The consistency of grout should be like toothpaste.
- ↳ Then work the grout into the tile joint with a grout float.
- ↳ Clean off any excess grout paste with the help of float and using damp sponge.
- ↳ Now leave the grout for three days.
- ↳ Now apply a penetrating grout sealant.

Advantages

- **Durability:** Granite highly resistant to scratches, chips and cracks making it perfect for high-traffic areas.
- **Heat resistance:** Withstand high temperatures, so it's ideal for kitchen and areas with heat exposure.
- **Low maintenance:** Once sealed, granite requires minimal maintenance. It's stain-resistant and easy to clean.
- **Variety of styles:** Various colors and patterns, offering plenty of design flexibility.
- **Long lifespan:** strength

Disadvantages

- **Cost:** more expensive than other flooring options especially for premium colors and finishes.
- **Cold & Hard:** quite cold and hard underfoot, which may be uncomfortable w/o heating systems.
- **Difficult Installation:** heavy and requires professional installation, adding to overall cost and complexity.
- **Sealing Needed:** needs to be sealed periodically to prevent staining and moisture damage.
- **Can be slippery:** when wet, can be slippery.

Factors affecting the selection of choice of flooring

- **Appearance:** Desired appearance; produce color effect in conformity with the use of building.
- **Cleaning:** Easily and effectively cleaned; effective resistance against absorption of oil, grease, etc.
- **Comfort:** Comfortable when used; if it possesses reasonably good thermal insulation then it imparts comfort to the residents of the building.
- **Cost:** less maintenance and initial cost.
- **Damp resistance:**
- **Durability:** Durable and strong enough to impart resistance to wear, tear, chemical action, temperature changes.
- **Fire resistant**
- **Hardness:** Hard enough to resist marks or signs caused by shifting or rubbing of furniture, equipment, etc.
- **Maintenance:** Easy to maintain.
- **Noise:** noise must not be created by flooring material (leads to discomfort).
- **Slipperiness:** should not be slippery.

Procedures

(1) Mud and ~~Mudram~~ flooring

- 25cm thick selected moist earth is spread and is then rammed well to get a consolidated thickness of 15cm.
- To prevent cracks due to drying, small quantity of chopped straw (acts as reinforcement) is mixed in moist earth before ramming.
- To maintain the mud floor in good condition, a thin coat of cow-dung mixed with moist earth or cement-cow dung in proportion of 1:2 to 1:3 is applied on the top.

(2) Murrum flooring

- 15cm thick layer of murrum is laid over prepared sub grade.
- Then 2.5cm thick layer of powder murrum (fine murrum) is uniformly spread.

→ The whole surface is well watered and rammed until the cream of the murrum earth rises to the surface.

- After dry and hard surface is formed, it is rubbed with thin paste of cow-dung and rammed again for two days during morning hours.

→ Finally, over the dry hard surface, a thin coat of cement cow dung plaster (1 cm: 4 cow dung) is applied evenly and wiped clean immediately by hand.

- Once a week, cow-dung should be applied.

(3) Brick-flooring

- Firstly, sub-grade is compacted and over this 10-15cm thick PCC is done.

- Now, brick are laid on 10mm thick bed of mortar.

- Joints are finished with mortar and properly cured.

(4) Flag stone flooring

- Sub-grade is prepared and then 10-15cm thick PCC is laid.
- Now, flagstones are laid over 20-25mm thick layer of mortar.
- Slope is necessary to be given in flagstone flooring for proper drainage.

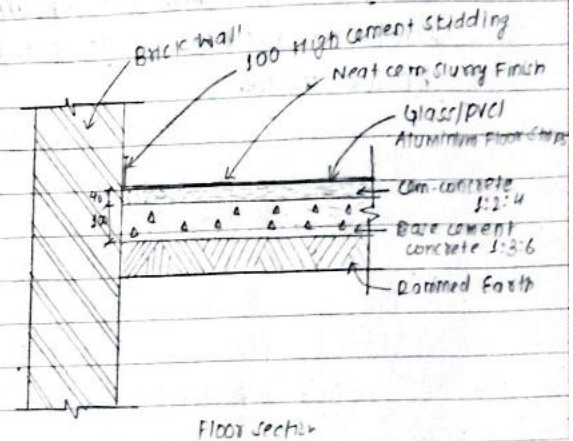
(5) Cement concrete flooring

Bare concrete

- First properly compact the earth in the plinth. While compacting, care has to be taken that a proper slope as required for the floor is provided.

- A base concrete of grade M10 (1 cm: 3 sand: 6 coarse Agg.) is then laid in the required slope and tamped properly. The thk. of base concrete is generally 100mm.

- Level the top of the base concrete and left it to set and harden.



Topping or Wearing Surface

- Thoroughly clean the surface upon hardening.

→ Divide the top of the floor into panels, rectangular or square in shape, by using glass or other strips. The area of the panels should preferably less than 2 square meters.

- After completion of the paneling, moist the top of the base concrete and apply cement slurry on it.
- Over this cement slurry, provide a layer of cement concrete of grade M15 (1:2:4) of required thickness (say 40mm)
- Tamp the top surface thoroughly to compact it and use wooden floats to obtain a smooth surface. The surface so obtained is cured for about 10 days before its use.

Timber flooring

- flooring made from solid wood planks or engineered wood, providing a natural and warm aesthetic to indoor spaces

Key points

- most commonly used in residential buildings (costlier)
- suspended type or solid type
- Dampness major problem so DPC layer provided below flooring.
- In hilly region, timber/woods → cheap, readily available, temp low so preferred.

Construction steps

- Prepare the subfloor:

Ensure subfloor is clean, dry and level

- Install underlay:

Lay down moisture-resistant underlay (like foam or plastic) to prevent moisture from damaging the timber.

- Acclimatize timber: (for at least 48 hours)

helps prevent expansion or contraction once installed.

- Start laying the timber planks:

Begin laying the first row of timber planks along the longest wall, leaving a small gap (usually about 10-15mm) from the wall for expansion.

- Fix planks in place:

Depending on the type of flooring (nail-down, glue-down or click-lock) secure the planks using nails, glue or by clicking them into place.

→ continue laying rows:

Continue laying the timber plank row by row, ensuring that the joints b/w the planks are staggered for a natural look.

→ Trim planks to fit:

Use a saw to trim any planks that don't fit around edges, corners, or walls.

→ Install transition and Molding:

at doorways and around edges

Molding - along walls to cover the expansion gaps.

→ Finish the surface:

If needed, sand the floor to smooth out any imperfections and apply a finish (varnish, oil, or wax) for added protection and shine.

→ Allow to settle:

Let floor settle and dry according to the finish's instructions before walking on it.

• Things to be considered in timber flooring:

→ Wood type: choose right type of wood (oak, maple, pine, etc.) based on durability, color and aesthetic preferences.

→ Acclimatization: Timber should be allowed to acclimatize to the room's temperature and humidity at least 48 hours before installation to avoid expansion and contraction.

→ Moisture levels: ensure subfloor and timber are dry
excess moisture → warping or swelling of wood.

→ Subfloor preparation: clean, level and dry to ensure proper installation.

→ Expansion Gaps: (usually 10-15mm) to allow wood to expand and contract with changes in humidity.

→ Finish and Coating: type of finish (varnish, oil, wax) → affects both appearance & durability.

→ Flooring Installation Method: choose b/w nail-down, glue-down or floating floor based on type of timber and your preferences for ease of installation.

→ Sustainability: ensuring it comes from a responsible, renewable source.

→ Maintenance: regular maintenance, cleaning, sanding & refinishing.

→ Room environment: Be mindful of the room's humidity and temperature, as extreme conditions can affect the wood's stability and longevity.

• Advantages:

- Durability (with proper care)
- Aesthetic appeal (natural look)
- Easy maintenance (simple sweeping, mopping & occasional refinishing)
- Increased property value (high end look & durability)
- Sustainable (eco-friendly compared to synthetic materials)
- Hypoallergenic (doesn't trap dust or allergens like carpet)
- Variety (wood types, finishes and colors)

• Disadvantages

- Susceptible to scratches or dent easily (pets, furniture)
- Sensitive to moisture: warping, swelling or shrinking
- Can be expensive: high-quality timber floor - costly installation
- Requires regular maintenance: periodic refinishing, sealing or oiling to maintain their appearance
- Noise (amplify footsteps or other sounds)

ii Rubber flooring

- versatile and durable option offering a range of benefits for both residential and commercial applications
- excellent choice for both residential and commercial spaces due to its practicality, safety and long-lasting performance.
- Used in areas that require impact resistance, sound insulation and slip resistance
- found in a variety of settings, including gyms, playgrounds, kitchen, hospitals and even residential spaces

Advantages

- Impact absorption
- Sound insulation (dense, cushioned nature of rubber)
- Eco-friendliness (made of recycled rubber, tyre scraps)
- Mould resistance
- Antibacterial properties (hygienic choice)

Disadvantages

- vulnerable to damage (easily gouged or scratched)
- Odor (odor of synthetic material)
- Fading and discoloration (prolonged exposure to sunlight)
- Not ideal for heavy traffic (wear down)
- Difficult to repair

Linoleum flooring

- ↳ Natural, ecofriendly flooring material made from linseed oil, pine resin, cork dust, wood flour and jute
- ↳ available in sheets, tiles or planks and is known for its durability, versatility and low environmental impact
- ↳ residential, commercial & healthcare spaces
- ↳ obtained in rolls, directly spread over concrete or wooden flooring
- ↳ 2-4m wide & 2-6mm thick

Advantages

- Eco-friendly and sustainable
- Natural antibacterial properties
- Durability
- Noise reduction (dense composition absorbs noise)
- Comfort and resilience (naturally softer)

Disadvantages

- Sensitive to moisture (not completely waterproof)
- Fading with sunlight
- Requires professional installation
- Harder to repair
- Initial cost

- Adv: Durability, waterproof, seamless installation (11), sound proofing (12), chemical & acid resistance (13), Aesthetic appeal (14), low maintenance (15)
- Disad: Soften at high temp, Installation challenges, Limited design variety, laid chemicals when freshly laid, slippery when wet, higher initial cost
- ## # Asphalt flooring
- ↳ made by combining asphalt with aggregates, fillers and sometimes fibers
 - ↳ durable, water resistant and ability to withstand heavy load

(1) Asphaltic Mastic Flooring	(2) Asphaltic Tiler Flooring	(3) Asphaltic Terrazzo Flooring	(4) Acid-proof Mastic flooring
Seamless & joint-free flooring made by mixing sand (or grit) and asphalt in 2:1 ratio	Pre-fabricated tiles made from a mixture of asphalt, asbestos fibers, inert material & mineral pigments	Decorative variant of asphalt flooring made by replacing sand with marble chips, quartz or granite	A special type of asphalt flooring designed for chemical & acid resistance
Installation process	Installation	Installation	Installation
- Mixture heated & laid in continuous sheet - A thin layer of sand spread over surface & rubbed to smooth it out - Can be applied hot or cold	- Mix is compressed into tiles 30cm x 45cm approx - Thickness 3mm to 6mm - Tiles are cemented to a concrete base or installed over a wooden floor with a mastic asphalt layer	- Asphalt heated & mixed with marble chips - Laid hot and smoothed for a polished look - Can be black or colored to match aesthetic requirements	- Manufactured by molding acid-proof asphalt with inert crushed rock - Asphalt blocks laid on concrete base - Liquid acid-proof asphalt laid over blocks & sand is added
Key properties	Key properties	Key properties	Key p:
- Highly water proof - Seamless - no joints, preventing moisture seepage - Durable under heavy loads	- Resilient & long lasting - Sound proof - Moisture proof - Low maintenance	- Highly decorative - smooth, polished & elegant - Durable - Easy to maintain with regular maintenance & staining	- Highly resistant to acids, alkalis & solvents - Prevents corrosion in harsh environments - Seamless & durable for long-term use
Applications	Appl:	Appl:	Appl
- Parking areas, warehouse, basement - Industrial buildings	Office, commercial buildings, & hospitals	Malls, hotels, museums, & high-end of floors	Chemical plants, laboratories & refineries

Core flooring

- natural eco-friendly
- made of bark of castor tree
- known for softness, resilience & insulation properties

Installation

- core harvested from bark of castor tree
- barks given compressed and baked to form sheets & tiles
- flooring is usually glued & sanded as installed or floating floor over an underlayment

Adv.

- Eco-friendly
- comfortable to walk
- Thermal sound insulation ✓
- water-resistant
- hypoallergenic

Disadv.

- Susceptible to damage ✓
- requires sealing ✓
- Fades in sunlight ✓
- Limited design options ✓

Appl.

Residential homes, Libraries & Offices, Yoga studios & gym

Glass Flooring

- transparent or translucent
- high-strength glass panels for modern aesthetics and light trans.

Instl.

- Selection of glass type
- Glass panels are cut & treated
- Frame installation (steel or aluminium) to support glass panels
- Glass is secured with sealants & fasteners

Adv.

- Modern and Stylish
- Light transmission
- Strong & durable
- Water & stain resistant
- Washable

Disadv.

- Slippery when wet
- Expensive
- Privacy concerns
- Prone to scratches
- Breakable under extreme impact

Appl.

- Skywalkers & observation decks
- Retail stores & showrooms (enhance product display)
- Museums & Art galleries

Plastic (PVC) flooring

→ synthetic flooring material made from polymeric compounds.

Installation

- glue-down (strong & permanent)
- Click-lock (DIY-friendly interlocking system)
- Loose lay (No adhesive)

Adv

- No odor
- easy to clean
- Affordable
- low maintenance
- Durable
- Variety of designs
- comfortable underfoot

Dis

- Not eco-friendly
- May release VOCs
- fading under sunlight
- cannot be refinished & may puncture easily

Floor & wall ties

- tensile connection that mechanically secure floor to walls, preventing separation due to lateral forces like wind, seismic activity, or differential activity
- These ties help maintain structural integrity by providing continuous load path.

Functions

1. Tensile strength

↳ prevents floors from pulling away from walls due to Hz. forces.

2. Load transfer

↳ transfer floor & wall, ensuring stability

3. Crack prevention

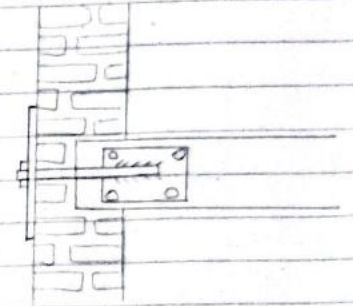
↳ caused by differential movement

4. Seismic & wind resistance

↳ strengthen connections against lateral and uplift forces.

5. Structural integrity:

↳ ensure floor and walls act as a single system.



Types

A. Steel and concrete structures

1. Anchor bolts
2. Steel plates and Angles
3. Rebar dowels

B. Masonry and timber structures

- Restraint straps (wall to floor)
2. Joist hangers
3. Timber to masonry ties
4. Brickwork ties for floor beams/walls

Roof

→ A roof may be defined as the uppermost part of the building, provided as a structural covering, to protect the building from weather (i.e., from rain, sun, wind, etc.). Basically, a roof consists of structural elements which support roof covering.

→ Structures like: truss, beams, slab, shell, dome, frames, etc.

→ Covering materials like: GI sheets, asbestos sheets, slates, wooden shingles, etc.

* Requirements of a Good Roof

(i) It should have adequate strength and stability.

(ii) It should effectively protect the building against rain, sun, wind, etc.

(iii) It should be water-proof and should have efficient drainage arrangements.

(iv) It should provide adequate thermal insulation.

(v) It should be fire resistant.

(vi) It should provide adequate insulation against sound.

(vii) Checks heat loss in winter and heat room in summer.

(viii) Aesthetically acceptable

* Types of Roofs

1. Pitched or sloping roofs

2. Flat roofs or terraced roofs

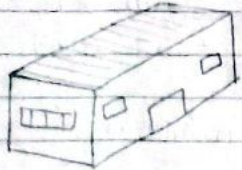
3. Curved roofs or shelled roofs

4. Domed roofs

1. Pitched or sloped roof (Roof having slope surface)

- Best for places with rains and snow is heavy
- Slope may be $10-70^\circ$ less than its flat and more than its wall.
- Pitch or slope is determined by its exposure and coverings.
- Slope towards the sun is generally not kept hotter places (away) and vice-versa.
- Easy for venting and drain snow and rains.
- Types:

- Lean to roof
- Gable roof
- Hip roof

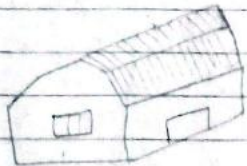


• Slopes in two direction



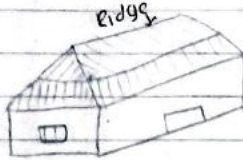
• Slopes in four direction

- Gambrel roof



- Slopes in two direction but has a break
- Vertical triangle

- Mansard or curb roof

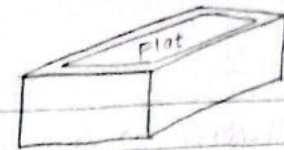


- Slopes in four dir but has a break

- Deck roof



- Slopes in four direction but has a plane or deck at top.



2. Flat roof

- Considered suitable for building in plain or in hot regions where the rainfall is scanty.
- Roofs are either horizontal (flat) or with slope less than 50° .
- Used in places with less rain and snow.
- usually used where roof space is needed to access on
- Small slope is used for water drain purpose

• Advantages:

- Roof space can be used for activities like functions, celebrations, gardening, restaurants, etc.
- Construction and maintenance is easy.
- Architectural appearance is good and property can be made attractive
- More stable in high wind places.
- No small attic places and no false ceiling is required.
- Is economical and for multistoried its used for tank placement and ventilation installment.

• Disadvantages

- span is shorter and intermediate columns are to be placed
- Self weight is high generally so must be designed properly.
- Unsuitable for places of heavy rain and specially snow areas.
- Proper water proof is needed as it retains water & snow.
- Initial cost is high & construction is slower

3. Shelled or curved roof

- Has thin section.
- Parabolic, hyperbolic, or segment of curve.
- Light wt and usually span is longer.
- Used for halls, airports, stations, stadiums, etc.



4. Domed Roof

- Curved roof area having more than semi-circle.
- Used for arch technology in bridges.
- Requires high skills and economy.
- Aesthetically appealing.

eg. Buddha Stupa.



Some terms in Roofs / Components

1. Span: clear distance b/w the supports of arch, beam, truss, etc.

2. Rise of roof: vertical distance b/w the wall plate and top of the ridge.

3. Pitch: inclination of side of roof to horizontal plane,

in x° or in ratio (1:2)

expressed as
angle in degrees

ratio of rise to span or
rise to corresponding run

$\left(\frac{\text{Rise}}{\text{Span}}\right)$

4. Ridge: It is the apex line of the sloping roof

↳ Spine of roof, where 2 pitch meet and are nailed together



5. Hip: Ridge formed by intersection of 2 sloping intersection surfaces, where exterior angle is greater than 180°

↳ Eaves: lower edge of inclined roof

↳ Valley: intersection of two slopes, just opposite of hip, external angle less than 180°

↳ Hipped end: triangular surface formed by b/w two hips at the end of roof.

↳ Verge: The edge of the gable running b/w eaves and ridge

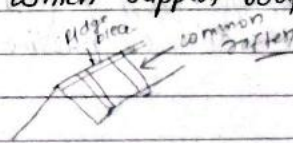
↳ Ridge piece: horizontal member in the form of beam or batten, provided at the apex of a roof truss which supports common rafters attached to it.

1. Common Rafters (Spar)

↳ inclined members running from ridge to eaves.

↳ Fixed to purlin at intermediate points.

↳ Support battens or boarding which support roof coverings.



12. Jack rafters:

↳ shorter in length

↳ run from valley or hip to ridge or eaves respectively.

13. Hip Rafters: (sloping rafters)

↳ Run diagonally from ridge to corner of the walls to support roof. Receive end of the purlins and end of jack rafters.

13. Valley Rafters

↳ sloping rafters that run diagonally from ridge to eaves for supporting valley gutters

↳ receive the ends of purlins and jack rafters.

14. Purlins:

↳ horizontal wooden or steel members used to support common rafters when roof is large.

↳ They are supported on trusses or walls

14. Eaves board or Eaves fascia:

↳ wooden plank or board fixed to the feet of common rafters at the eaves

14. Wall plates

↳ wooden members provided on walls for purpose of fixing the feet of the common rafters

↳ Placed at center of wall connecting roofs to wall

15. Battens

↳ thin strips of wood (called scantlings) fixed on rafters to prevent purlin to slide down.

15 Template

↳ square or rectangular block of concrete placed under a beam or truss to spread the load under a larger area of wall.

16 Dragon ties

↳ placed across the corners and over the wall plates and help to provide a fixture to hip rafters.

17 Ceiling joist

↳ wooden members that function as ties to the feet of the rafters and provide support to ceiling boards underside and clear house within the roof void.

18 Struts

↳ compressive members that transfer load of purlin to suitable load bearing structure.

19 Cleats: small pieces of wood fixtured on rafters to prevent purlin to slide down.

20 Verge: It is the edge of roof covering

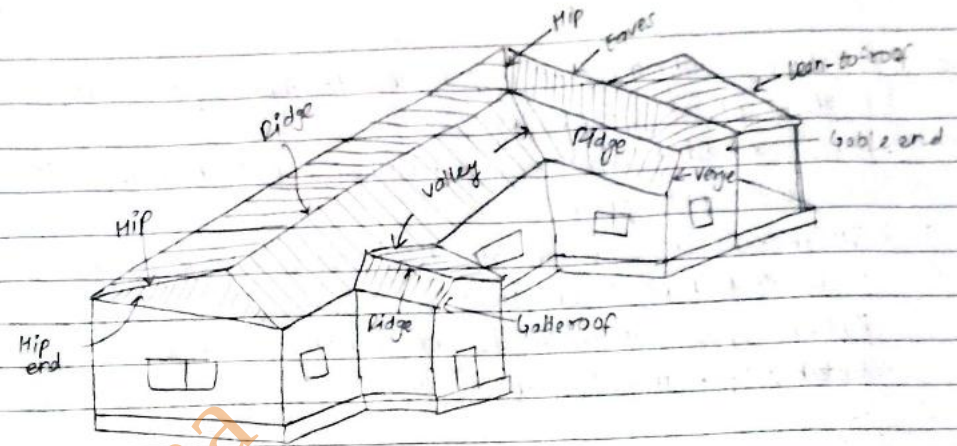


Fig: Pitched/sloping roof and its elements

Timber Roofs

- Single timber roofs
- Double timber roofs (or purlin)
- Multiple timber roofs (or trussed)

(i) Single Timber roofs

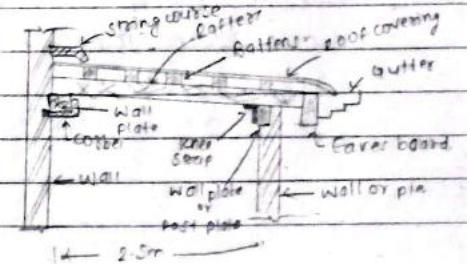
↳ the common rafters are provided to each slope w/o any intermediate support

↳ used only when span is limited to 5m.

• Types

(a) Lean-to-roof

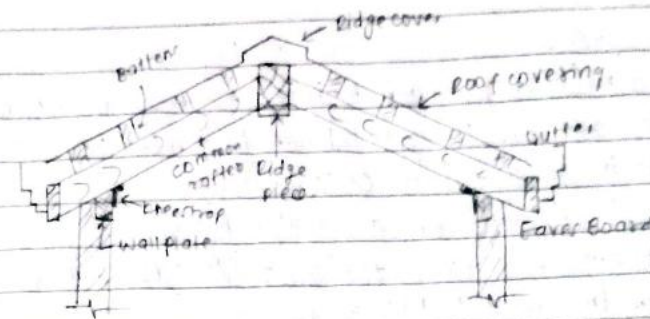
- sloping at one side
- span of 2.5m only
- shed, outhouse attached to main, etc.
- simplest type of pitched roof



- At upper ends rafters are nailed to the wooden wall plate placed at eave.
- At lower end rafters are notched & nailed to the wooden post plate.
- Difference in elevation b/w two plates is so kept the desired slope is obtained i.e. 3%
- Batten spaced at 15cm c/c are nailed to rafters
- Suitable for max^m span of 2.4m

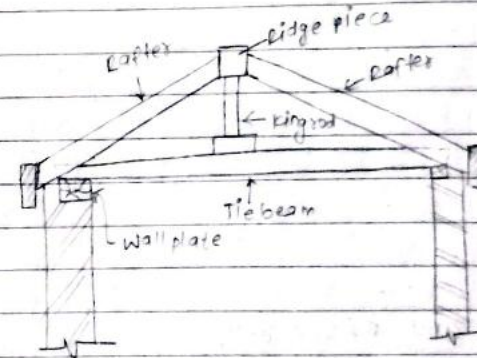
(b) Couple roof

- formed by pair of rafters slope upward from the opposite walls and they meet on a ridge piece in the middle.
- Upper ends → nailed to common ridge piece
- Lower ends → notched and nailed to the wooden wall plates
- Batten are nailed on the rafters and roof covering is laid.
- Such roof is not very much favoured because it has tendency to spread out at the feet and thrust out the wall supporting the wall plate
- It is suitable for spans up to 3.6m
- It is used for the shed and small buildings and also as a storage building.



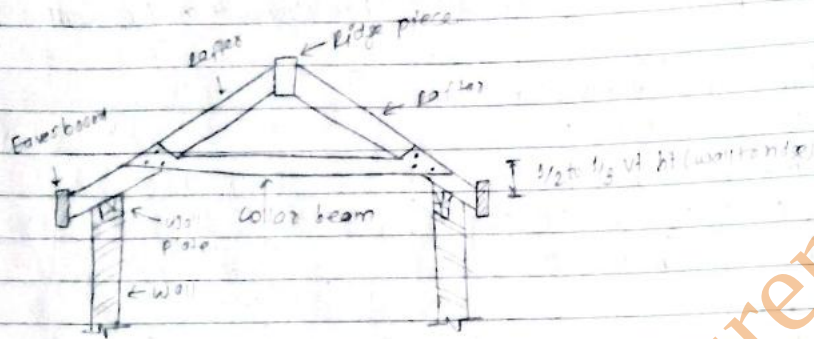
(c) Couple closed roof

- Similar to couple but has a horizontal member called tie beam to prevent spreading and thrusting out of the wall.
- Tie beam also prevents the danger of overturning of the wall.
- The connection b/w tie beam and feet of rafters is called dovetail halved joint
- Tie beams can also be used as ceiling joist when required
- Suitable for spans up to 4.2m
- For increased span, vertical member called Kingrod is introduced b/w ridge piece and center of the tie beam to prevent from sagging



(i) Collar beam roof

- When load in roof or span is more, rafters tend to bend, to overcome this tie beam is raised and placed at the higher level called collar roof.
- The beam is also known as collar beam.
- collar beam is usually fixed at $\frac{1}{3}$ rd to $\frac{1}{2}$ vertical ht. from the wall to the ridge.
- A collar beam roof is adopted to economise the space and increase the height of a room.
- The lower is the collar, stronger is the roof.
- Suitable for maximum span of 4-8m.



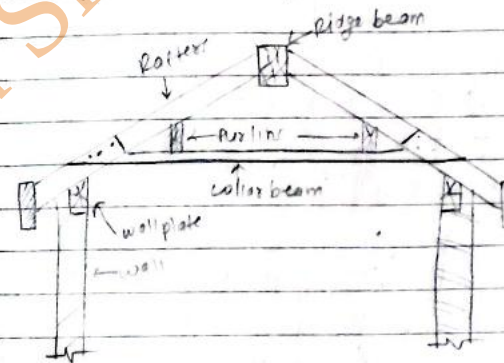
(ii) Collar and scissor roof

- Similar to collar roofs but beams cross each other like scissors.



(iii) Double or purlin timber Roof

- consists of two basic elements purlins and rafters.
- Purlins give the intermediate support to the rafters and supported on end walls.
- To reduce the size of rafters, purlins are also introduced.
- Effective span of the rafter is thus nearly halved and it becomes much lighter.
- Each rafter is thus supported at three points:
 - (i) at the bottom on wall through wall plate
 - (ii) at the top by ridge beam
 - (iii) at the center by a purlin
- For larger roofs, two or more purlins may be provided to support each rafter.



(iii) Triple Membered or Framed or Trussed Roofs

→ When the span exceeds 9m and there is no inside walls to support the purlins, the framed structure, known as trusses are used.

→ Spacing of the truss depends on load on the roof, position of cross-wall span and material of truss but generally 3m.

→ This system of roof consists of three elements

- i. Rafter to support the roofing material.
- ii. Purlins to provide intermediate support to the rafter
- iii. Trusses to grant support to the ends of purlins

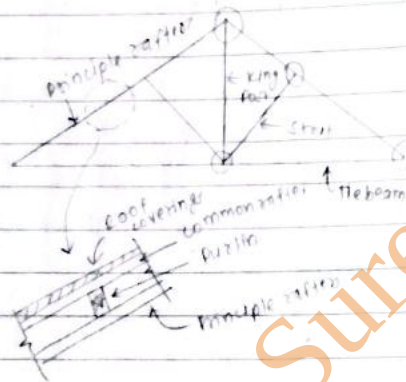
Types:

(a) King-Post truss

→ consists of

- Lower tie-beam
- Two inclined principle rafters
- Two struts
- King post

→ It is used in small to medium buildings such as houses, garage, etc.



→ [Principle Rafter] → support → [Purlins] → support → [Common Rafter] → support → [Roof Covering]

→ Tie beam prevents the wall from spreading out due to thrust.

→ Struts prevents principle rafter from bending in the middle

Span = 5 to 9m

→ Ridge beam provide support to the common rafters

→ Trusses are supported on the bed block of stone and concrete embedded in the supporting wall to distribute loads in greater roof area

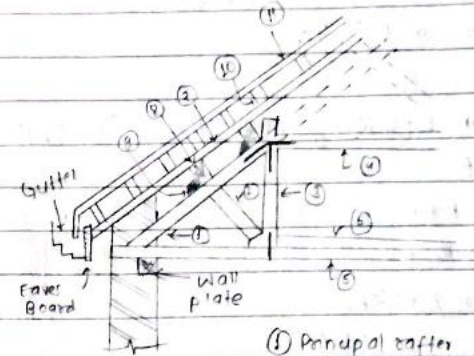
Joints are provided between

[Rafter & tie beam] [Principle Rafter & King-post] [King-post & beam] [at the end of struts]

(b) Queen-Post truss

→ consists of

- Lower tie-beam
- Two inclined principle rafters
- Two struts
- 2 Queen-posts
- Straining Beam



→ Principle rafters support purlins and purlin supports common rafters.

- | | |
|--------------------|-----------------|
| ① Principle rafter | ⑦ Common rafter |
| ② Strut | ⑧ Purlin |
| ③ Queen-post | ⑨ Cleat |
| ④ Straining beam | ⑩ Battens |
| ⑤ Tie beam | ⑪ Sheeting |
| ⑥ Straining sill | |

→ suitable for 8-12m span. (9 to 14m)

→ Upper end of queen post is connected by hz. member called straining beam

→ Queen-post are the tension members

→ Straining beams receives thrust from prin. rafters and keeps junction at stable position

→ Straining sill is introduced on tie beam b/w queen post to counteract the thrusts on inclined struts which are in compression.

→ The joint at the head of queen-post is made from the combination of tension member (Queen-post) and compression member (principle rafter and straining beam).

→ Head of queen-post is made wider & head of p. rafter and end of straining beam is tenoned into it.

→ Joint is strengthened by 3-way strap of wrought iron.

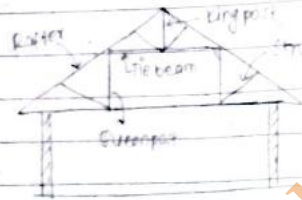
→ Joint is further strengthened by straps and bolts.

(c) Combination of King-post and Queen-post truss

→ consist of

- King-Post
- Queen-Post

→ Suitable for greater than 12m.



(d) Mansard roof truss

→ consist of

- King-post (upper)
- Queen-post (lower)

→ two storey truss

→ It has two pitches

i. Upper pitch (king-post truss) varies from 30° to 40°

ii. Lower pitch (queen-post truss) varies from 60° to 70°



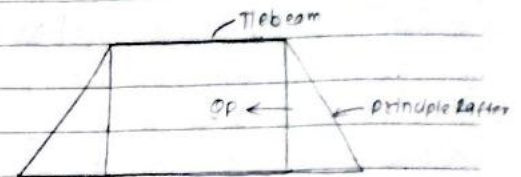
→ It provide economy in space and a room may be provided in the roof b/w two queen post

→ It is not used at present due to its odd and ugly appearance and also introduction of steel truss.

2) Truncated truss

→ used when it is required to provide a rooming roof, b/w two queen-post of the truss.

→ similar to Mansard truss except that the top is finished flat with a gentle slope to one-side



f) Bel-fast (bow string) truss

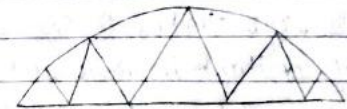
→ Truss in the form of bow

→ consist of thin-sections of timber with its top-chord curved

→ can be used for long span of about 30m with light roof covering.

→ also known as latticed

roof or low string truss



(g) Composite roof truss

- Composite of 2 materials like timber and steel etc
- Any other type of roof truss with combination of materials are used.

Steel-Roof trusses

- when span exceeds 10m, timber trusses become uneconomical and heavy.
- For longer span, steel trusses are used
- are fabricated from rolled structural members like channels, angles, plates, hollow sections, etc.



Advantages over timber truss:

- Readily available in required dimensions, resulting in minimum wastage of materials
- Fire-proof
- Termite-proof
- More resistant to other environmental agencies and have longer-life.
- Quick and easy fabrication.
- can be used for longer spans unlike timber elements
- Stronger and rigid compared to timber trusses.

- (viii) ~~High~~ For a given strength, they are light in weight and can be fabricated in any shape depending upon structural and architectural requirements.

* Angular Steel roof truss

- Steel trusses are commonly fabricated using angle sections and plates.
- Designed to carry direct stresses only (tension and compression) no bending.
- Three major components:
 - Top chord: includes principle rafter, which is generally made up of two angle sections placed side by side.
 - Bottom chord: includes main tie, made similar as top chord.
 - Strut and Tie: generally made up of single angle section.
- Bracing is provided to connect two trusses together.
- These members are jointed together using Gusset plate, through riveting, bolting or welding.
- Following norms are considered if riveting is done:
 - Minimum pitch $\geq 3 \times$ rivet diameter
 - Max π pitch = 150mm (for comp. members)
= 200mm (for tension members)
 - For small span, 15mm dia. rivets are used
 - For large span, 20mm dia.
 - At least 2 rivets should be used at each joint.
- Minimum thickness of Gusset plate should be 6mm.

- Clots: very small boxes. kind of member which do the welding in site and they contain holes for bolting connection in site. Main function is to prevent the tilting of purlins.
- Strut $\Rightarrow$ compression member • Tie $\Rightarrow$ tension member

* Tubular steel roof truss

- $\rightarrow$ Generally, used for large span exceeding 8m for factories, halls, etc.
- $\rightarrow$ Members are usually joined by welding.
- $\rightarrow$ Light weight and economical.
- $\rightarrow$ Members are in direct stress.
- $\rightarrow$ Can be fabricated in workshop and fitted in site or directly fabricated in site.
- $\rightarrow$ Purlins however are provided with holes with threads at their ends whereas principle rafters have a rectangular plate (with holes) welded to their ends and are connected together.

• Advantages of tubular truss

- $\rightarrow$ 30 to 40% less surface area than that of an equivalent rolled steel shape. Therefore, the cost of maintenance, cost of painting or protective coating reduce considerably.

- $\rightarrow$ The moisture and dirt do not collect on smooth external surface of tubes. Therefore, possibility of corrosion also reduced.
- $\rightarrow$ The ends of tubes are sealed. As a result of this, the interior surface is not subjected to corrosion, and don't need protective treatment.
- $\rightarrow$ More to axial resistance than other section of equal weight.

Roof coverings for Pitched Roofs:

- $\hookrightarrow$ placed over roof frame work
- $\hookrightarrow$ protect from different climatic conditions and atmospheric agencies

• Factors to be considered while selection of Roof coverings:

- Durability**: Different materials $\Rightarrow$ Different lifespan
Select more durable.
- Climate of the place**: Should withstand every climatic condition of the place to avoid roof damage.
- Weight**: With age building loses its strength
Using low-wt. roofing material like asphalt, overall pressure on building can be reduced and helps to maintain the building's integrity.
- Resilience**: Designed to withstand different natural disasters and also provide chemical resistance.
- Initial cost and Maintenance cost**: Should have long-term value and durability.
- Resistance to fire and heat**.
- Availability of materials**.

Types of Roof coverings in Pitched Roofs

(i) Thatch covering

- Cheapest and light-weight
- Highly combustible and unstable against wind
- Abrasive texture and viable to rot
- Organic materials found in natural environment is used: Vegetation, rice straw, wheat straw, etc
- Slope $> 40^\circ$ (to drain the roof),
- thickness 30-15cm,
- batten distance 30cm.

(ii) Wood shingles:

- thin slab of wood
- obtained either by sawing or splitting the well seasoned timber wood.
- obtained in length varying from 30 to 40cm and width varying from 6 to 25cm.
- Specially used in hilly area of Nepal (wood is easily available & cheap)
- light weight
- Not fire and termite resistant

(iii) Tile roofing

- Oldest roof coverings and are still in use
- clay or concrete tiles
- Manufacturing process similar to manufacture of bricks.
- long-lasting and can withstand harsh weather conditions.

→ Aesthetically appealing (variety of colour and style)

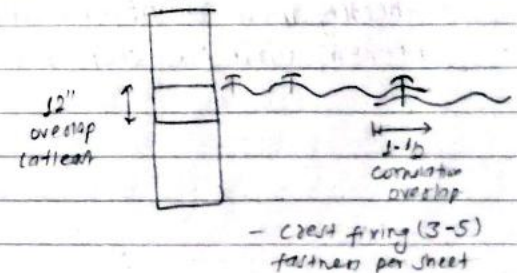
- 20-45° slope
- 265 x 165mm standard size of tile
- Interlocking to prevent water drip in.
- overlapping is lap and gauge is interval and given by $\text{gauge} = (\text{length of tile} - \text{lap}) / 2$

(iv) Arbestos cement sheets (A.C. sheets)

- combination of cement with about 15% of asbestos fiber
- cheap, lightweight; tough, water resistance and doesn't require any protective paint
- have low thermal conductivity and are widely used in Industries, workshop, cinema house, etc.
- High speed of construction, low maintenance cost
- Possibility of getting damaged due to external load.
- 2-3 m in lengths.
- Laid similar as CGI sheets.

(v) CGI sheets (Corrugated Galvanized Iron)

- Sheet of steel that have been coated with layer of zinc through a process of galvanization.
- This coating provides protection from rusting action of water and wet weather.
- Stronger than AC sheet.
- Cost: Higher than AC
- Lighter than AC
- less possibility of damage due to external load.



(vii) Slate

- hard, fine-grained sedimentary argillaceous (clayed), natural stones obtained from open quarries or mines.
- Size of slate varies from 600mm x 300mm to 400mm x 200mm and thickness varies from 4mm to 10mm.
- Good slate should be hard, long-lasting, tough, rough-texture, not split when holed or drilled, practically non-absorbent and of satisfactory colour.
- So laid s.t. each slate overlaps a slate in the next course, but below it.
- Fixed by nailing in battens.

(viii) Light-weight Roofing

- For wide-span industrial structure, it is desirable to reduce weight of roof so that structural framing can be economized.
- Consists of sheeting:
 - Aluminium sheet
 - Asbestos cement sheet
- Conditn of decking:
 - Wood wool
 - Straw board
 - Aluminium alloy and steel decking
- Sheetting used for sloping roofs.
- Decking used for sloping as well as flat & roofs.

(viii) Fiber sheets

- advanced and modern roofing
- available in different size and thickness
- made up of high grade raw material
- provided with ultra glow polymer coating for maximum 3D effect.

* Factors to be considered while selecting roof covering material

Chapter - 5

Stairs, Lifts and Escalators

- Buildings various spaces are connected by connector parts.
 - Horizontal connector (passage, corridor, hall-way, lobby, etc.)
 - Vertical connectors (stairs, lift, escalator, etc.)

Stairs:

- set of steps suitably arranged for the purpose of connecting floors of a building.
- consist of 2 way flow with no mechanical means.
- constructed to provide easy, comfortable, and safe ascent/descent with series of steps that are neither laborious nor difficult to climb within an enclosure called stair-case.
- opening or space occupied by the stairs = stairway.
- Need no operation cost and must be present in every building even in form of hazard escape route.

• Functions:

- Provide normal everyday access from floor to floor
- Provide easy and rapid escape, from the upper floor in case of emergency such as earthquake, fire, etc.

* Elements of stairs:

1. Tread / Going: HZ. member (width) where foot is placed

↳ member b/w two risers.



2. Riser: VT. member supporting tread

↳ b/w 2 treads

↳ gives ht. to the steps

↳ No. of riser is given by VT. difference of floor levels.

7. Flight: continuous series of steps w/o any landing in their direction

8. Nosing: the exposed edge of tread which is projected outward

↳ square or rounded edge

9. String/Strings: member receiving end of the step

↳ inclined boards or beams that run along the slope of stairs, providing support to the steps

↳ May be open or closed strings

10. Head room: min^m vertical distance b/w tread and overhead structure (ie. ceiling, etc.)

11. Hand rail: protective bar at the top of balusters which provides support for the hand.

12. Soffit: under-side of the flight structure

13. Skirting: moulding provided under nosing to improve elevation, the steps and to provide strength to nosing.

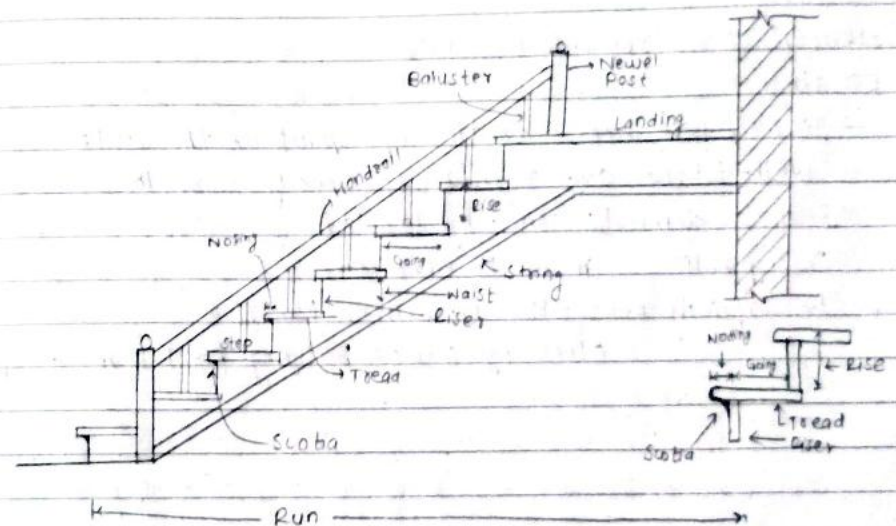
3. Step: one combination of a riser and a tread

4. Staircase: the enclosed volume where stairs is accommodated.

5. Stairway/Stairwell: Space where stairs is housed.

6. Landing: platform left in b/w 2 adjacent flight for circulation and rest

↳ resting place during ascending & descending



Elements of staircase.)

13. Baluster: vertical member to support the handrail and placed b/w step and hand rail

↳ combined framework of handrail and baluster

↓
Balustrade

14. Newel post: A wooden, steel post supporting the hand rail and is usually provided at the starting of the flight

15. Pitch line: an imaginary line connecting the nosing of all steps in the flight.

Pitch: angle made by pitch line with hz.
(or slope)

16. Run: Total length of stairs in a hz. plane, including landings.

* Essential Requirements of stair

1. Location

- provide easy access to the occupants of the building
- well-lighted and ventilated directly from the exterior
- For residential: centrally located
- For public: near to entrance
- For apartments: one in central location other by side of building for hazard escape

2. Width of stairs:

↳ wide enough to carry user w/o crowd or inconvenience

↳ Depends on its location and type of building.

↳ Normally, Public: 1-1.8 m
Residential: 900mm. } check NBC

3. Length of Flight:

✓ ↳ Min^m 3 to max^m 12 steps

4. Slope of stairs

↳ comfortable for user.

↳ In general, 25° to 40°

5. Head room:

↳ clear distance b/w tread and soffit of flight should not be less than 2.1m or 7ft.

↳ should be made considering a tall person can wear it with some luggage on his head

6. Materials

↳ strong and safe as per utility and durability

7. Balustrade

↳ provided to minimize danger of accidents.

8. Landing: width of landing $\geq$ width of flight

9. Windows: Tapering steps to change the direction of flight

↳ should be avoided as far as possible.

↳ Not suitable for public stairs with more users.

30. Step dimensions

↳ Rise and tread should be of uniform dimension throughout the staircase st. to provide comfort to the users.

↳ Step proportions:

$$T + 2R = 60 - 64 \text{ cm}$$

$$T \times R = 400 - 426 \text{ cm}^2$$

$$T + R = 40 - 45 \text{ cm}$$

↳ Standards:

• Residential: $T = 22 - 27 \text{ cm}$ & $R = 15 - 17 \text{ cm}$

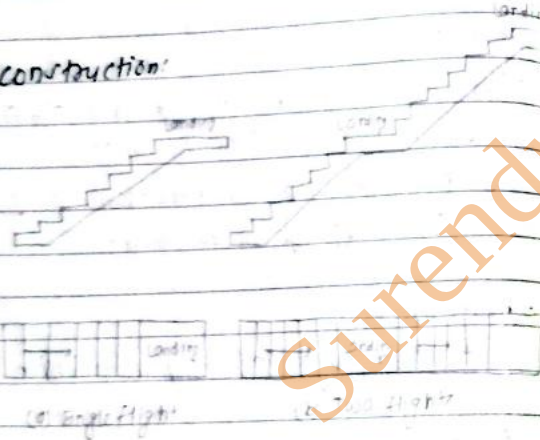
• Public: $T = 25 - 30 \text{ cm}$ & $R = 10 - 15 \text{ cm}$

* Types of stairs

• According to method of construction:

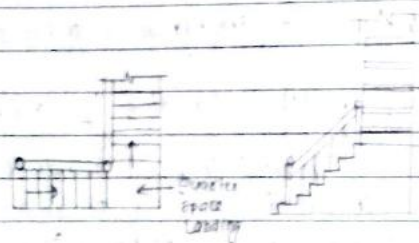
(i) Straight stairs:

- Floor to Floor
- with or w/o landing
- Simple
- Economical
- Traditional
- Used where space is limited.



(ii) Quarter-turn stairs

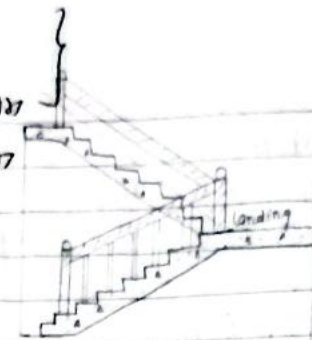
- 2 st. flights at 90° turn with quarter space landing.
- Economic/compact
- Windows may be provided for economy/space saving.



- (i) → Straight stairs
- (ii), (iii), (iv), (vi) → Turning stairs
- (v), (vii), (viii), (ix) → Continuous stairs
- (iii) Dog-legged / Half-turn stairs

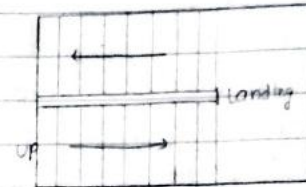
• Two st. flights at 180° turn with mid landing

- Rises parallel to the lower flight
- consumes less space



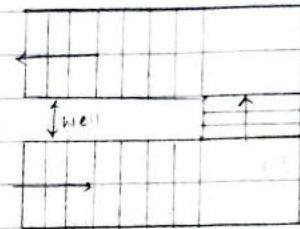
↳ landing half space / half turn

- mostly used.
- Popular in residential building in Nepal.



(iv) Open well / Open Newel

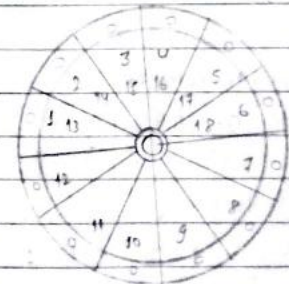
- Two or more straight flights arranged around a well or space.
- Similar to dog-legged but with larger space in b/w flights
- Used in public buildings



(Plan)

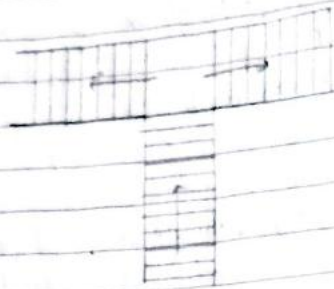
(v) Spiral Stairs

- Economical
- Suitable where little space is available
- Made from steel and welded together however it is possible to make from wood.
- Not very safe since they generally have winded steps
- Commonly used in terraces in Nepal.



(vi) Bifurcated stair

- Extravagant
- used in prestigious buildings
- wider stairs split into two narrow stairs in 2 direction.



(vii) Geometrical stair

- like well but in curve and some steps are winders



(viii) Circular

- curvilinear with appearance.

(ix) Helical

- all steps are winders used in aesthetical places



• According to Materials used

(1) Timber stairs

- Light in wt.
- Easy to construct
- Poor resistance to fire
- used only for small-residential buildings.
- unsuitable for high-rise, public and commercial buildings.
- Timber used should be free from fungal decay and insect attack

(2) Steel stairs

- Made up of mild steel or cast iron
- used in very exceptional cases as emergency stairs (fire escape)
- Doesn't look good and makes a lot of noise while walking.
- Regular maintenance required.
- Both steel tubes and angles are used.

(3) Concrete stairs

(a) Cast in-situ concrete stairs

- Form of stairs and individual treads and risers may vary as desired.
- Casting takes time to set up framework and time to cure
- Casting in uncertain condition can lead to inconsistencies in final product
- Construction is slow and weather dependent

(b) Precast concrete stairs

- Better quality control
- Fast and easy installation
- manufactured in controlled environment to ensure accuracy of final product
- Once excavation has been completed precast pits can be installed immediately

- Casting in-situ requires time and this time needs to be factored into overall project timeline estimates

- Using precast products, improves efficiency in construction timeline,

- Saving in site space; no space required for fabrication.

- Can be fixed and positioned by semi-skilled labour.

(4) Stone stairs

- Used very little today due to high cost and weight
- Used in old structures and in rural areas
- High strength and longevity

(5) Brick stairs

- Used generally for external use
- Steps must be made from good, hard bricks to withstand wear.
- Bedded in cement mortar or concrete

Design of stairs

1. Rises and Tread ratio

a. Residential buildings

R : 150mm to 170mm [175] (I)

T : 220 - 350mm [250]

Slope: $35^\circ - 45^\circ$

Unobstructed width: 0.8 to 1m

(b) Public building

R : 100 - 180mm [150]

T : 280 - 350mm [300]

Slope: $27^\circ - 33^\circ$

Unobstructed width: 1.8 - 2m

Procedure to Design

(i) Calculate level diff. b/w 2 levels

(ii) Assume building type & stair. & accordingly R.

(iii) No of rises (N_R) = $\frac{\text{Level diff}}{\text{Rise size (R)}}$

(iv) No of Tread (N_T) = $N_R - 1$

(v) Assume width size of tread similarly as (ii)

$\left[\begin{array}{l} 2R + T = 600\text{mm} \\ R \times T = 400 - 450 \text{ sq. cm} \end{array} \right] \leftarrow \text{Thumb rule}$

(vi) Assume width as per utility & building type

(vii) Width of landing = width of stairs (or as per requirements)

(viii) Consider entry space (E) equal to landing (generally)

(ix) Find total length of stairs = $(N_T \times T) + L + E$

Q1 Design a staircase for a residential building for given space of $2.1m \times 5m$ with the floor height $3.3m$. Assume necessary data and draw a neat sketch to support the design.

→ Soln

Given,

Floor ht. of staircase = $3.3m$

Size of staircase = $2.1m \times 5m$

Type of building = Residential

1. Assuming type of staircase = Dog-legged: 2 nos of flight
2. Assuming width of staircase = $1m$
3. Assuming width of landing = $1m$ (Gen, equal to width)
4. Height of one flight = $\frac{\text{Floor ht}}{2} = \frac{3.3}{2} = 1.650m$

5. Assume ht. of riser (R) = $150mm$

6. No. of rise in each flight = $\frac{\text{Ht. of one flight}}{\text{Ht. of Riser (R)}} = \frac{1.650}{0.150} = 11 \text{ Nos.}$

7. No. of tread in a flight (N_T) = $N_R - 1 = 10 \text{ Nos.}$

8. Width of Tread (T),

$$T + 2R = 600mm$$

$$\Rightarrow T = 600 - 2 \times 150 = 300mm$$

9. Length of stairs = Tread (T) $\times$ N_T + width of landing

$$= 300 \times 10 + 1000$$

$$= 4000mm$$

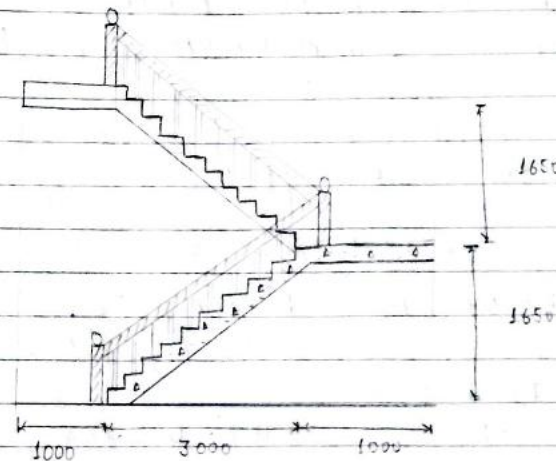
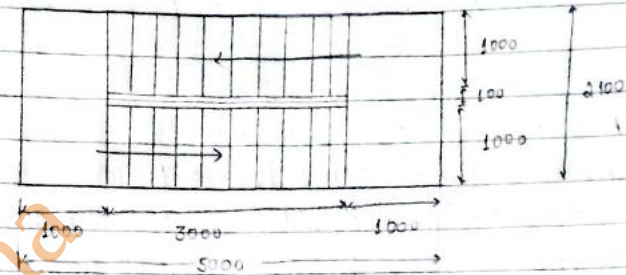
10. Entry space (space available for passage)

$$5000 - 4000$$

$$= 1000mm$$

Hence, Total number of tread = $10 \times 2 = 20$

Total number of Rise = $11 \times 2 = 22$



Q2 Design a suitable staircase for public building in a hall of size $5.5\text{m} \times 7.5\text{m}$. The vertical distance b/w floor is 3.5m and RCC slab thickness is 150mm . (Assume any necessary criteria, if required). [2074 Rhodoe]

→ Soln:-

Clear space b/w floors = 3.5m (CS)

Thickness of RCC slab (tea) = 150mm

Building hall size for staircase = $5.5\text{m} \times 7.5\text{m}$.

• For public building, adopt an open newel stairs with a rectangular well.

The space of well may be utilized for provision of a lift.

1. Take $R_{\text{te}}(R) = 100\text{mm}$ for public building.

2. Total ht. of floor = clear distance b/w floors + tea
 $= 3.5 + 0.15$
 $= 3.65\text{m}$

$$3. N_L = \frac{3650}{100} = 36.5$$

take 37 number of riser.

4. Actual, ht. of steps i.e. Rise (R) = $\frac{3650}{37} = 98.6\text{mm}$

5. T: $T + 2R = 600$

$$\Rightarrow T = 600 - 2 \times 98.6 = 402.8\text{mm}$$

take $T = 400\text{mm}$

Here, from out of 37 riser, provide 14 riser in 1st flight, 9 in 2nd flight and 14 in last flight.

6. Now, width of stairs = width of landing
 $= \frac{(\text{width of stairs hall} - \text{space occupied by middle riser})}{2}$

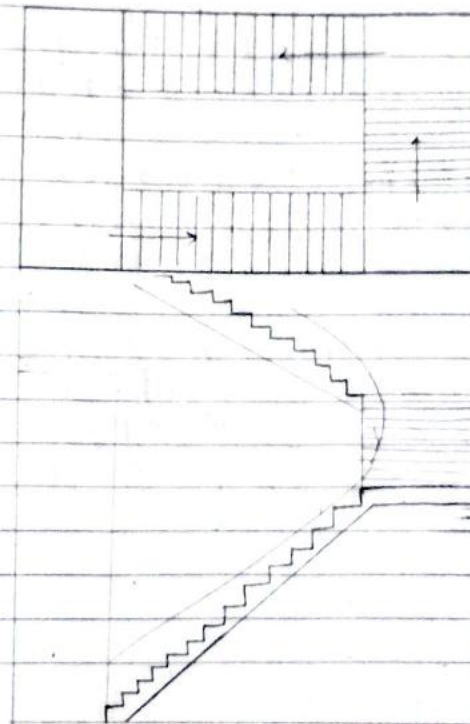
$$= \frac{(5500 - 3200)}{2}$$

$$= 1150\text{mm} \quad \text{8} \times 400$$

7. Spacing left for passage = length of hall - space occupied by first/last flight
 $= \text{width of landing}$

$$= 7500 - 13 \times 400 - 1150$$

$$= 1150\text{mm}$$



1. Ladders

- vt or inclined set of rungs or steps used for climbing or descending.

- need to be leaned against wall (except stepladder)



2. Rigid ladder

- can be leaned against vt. surface such as walls, electric poles, etc.
- usually portable
- originally made of wood but in 20th century aluminium became more popular (light weight)
- ladders with fibres glass are used for working on or near overhead electric wires



2. Rope ladder

- hung from the top
- Traditionally used for honey hunting, painting work, etc.
- used where storage space is extremely limited, weight must be kept to a minimum
- used in instances where object to be climbed is too curved to use a rigid ladder

Lift/Elevator

- A lift or an elevator is an appliance designed to transport living beings or materials between two or more floors in a vertical direction by a means of a guided car or platform.
- when level of travel is too high to take stairs and for transport of loads, lift are used.
- Easy to use but O&M cost is high

NBC(206) (check)

- Provision of lift shall be made in all buildings more than 15000 mm in height
- Not more than 4 lift shall be provided per bank.
- Shafts for lift will have to be enclosed by wall having fire resistance of two hours
- Lift wells that extend for more than two floors shall be ventilated to outside air through opening of not less than 3.5% of the area of the shaft.
Lift wells shall not be vented directly through the machine room and provision of enclosed ventilation ducts or pipes should be provided through the machine room in such case.

* Types:

Traction lift	Hydraulic lift
→ based on <u>see-saw principle</u>	→ based on <u>Pascal's Pressure Principle</u>
→ <u>Lifted by ropes</u> , which pass over a wheel attached to an electric motor above the elevator shaft	→ <u>Supported by piston</u> , at the bottom of elevator that pushes the elevator up as the electric motor forces oil or another hydraulic fluid into the piston
→ Used for <u>mid and high rise</u>	→ For <u>low-rise applications</u> of around 2-5 stories
→ Much <u>higher travel speed</u> than hydraulic	
→ components: control system, motor, sheave, motor counterweight, guiding rail	→ components: tank, motor, valve, actuator
→ The machine room is located at <u>uppermost level</u> i.e. on the terrace	→ <u>the lowermost level</u> adjacent to the elevator shaft

- * Types:
- Passenger lift
 - Goods or service lift
 - Open lift

* Terminologies

- Car body
- Suspension cables
- Liftwell or lift shaft
- Machine room
- Call indicators or floor indicators
- Buffers: dampers for soft landing at base
- Guide rails

* Prescription for lift/Escalator

- More than 13m ht. lift must be provided.
- 1 lift per 20 tenements of all floors or 1 per 1000 sqm part of built-up area
- Generally assumed to be used by third floors ~~to above~~ & above
- In building, ≥ 21m ht. at least 2 lifts are provided.

Escalator

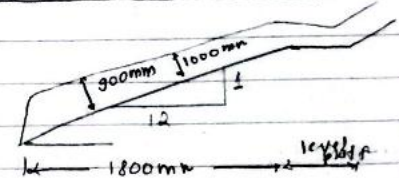
- A moving staircase - a conveyor transport device for carrying people b/w floors of building
- Consists of motor-driven chain of individual linked steps that move up or down on tracks, allowing the steps & treads to remain horizontal
- Used to move pedestrian traffic in places where elevators would be impractical like shopping malls, airports, convention centers
- consumes less power as compared to lift
- possess large capacity (About 8000 persons per hour by escalator of width 1.2m)
- continuously operating mechanical stairs
- Generally only 1 level transport

Ramps

- sloping surface adopted as a substitute for stairs for easy connection b/w floors
- stairs without steps i.e. slope only
- slope depends on type of use
- used for differently abled people in public & semi-public places
- also used in garages and parking
- NBC 206

- Access ramps for wheelchairs shall not have gradients in excess of 1:12.
- Level platforms shall be provided at max^m 1800mm flight
- The minimum width of wheelchair accessible ramps shall be 900mm for apartment and residential use, and 1000mm for other building types.
- Handrails are required when total rise exceeds 600mm.

- Firefighting must not be affected.



Important features of Ramps

- provided mainly in public buildings where movement of people is very large.
- Ramp surfaces should be stable, firm and slip resistant. Normally finishing of floor of ramps is provided with non-slippery tiles
- Exposed exterior ramps and their approaches are constructed to prevent the accumulation of water on walking surfaces