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Er. Iswor Rawat

Engineer

Building Construction Technology

Building Building is the one of the most important structure constructed by a civil engineer.

Parts of Building

ⓐ Sub-structure → The portion of building below ground level.

→ Example: Foundation

ⓑ Super-structure → The portion of building above ground level.

→ Example: Wall, Door, Window, roof etc.

Note: The portion of building between ground & floor level is called plin

→ The minimum height of plinth level from existing road level = 45cm.

Foundations

Foundation is the lowermost part of structure that transfers load from superstructure to the sub-soil which is in direct contact to sub-so

Sub-soil Exploration

The main objectives of soil exploration is to know the general picture of the geography of that area to get adequate information of typ & nature of soil available at different depths for designing safe, sour economical foundation for structure. → first step in design of foundation. → It mainly consists of boring, sampling & testing.

Objectives/ Function of Sub-soil Exploration.

→ To select the type of foundation (shallow, deep) to be constructed

→ To determine the bearing capacity of soil.

→ To predict the different settlement.

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→ To know the ground water table.
→ To know the suitability of soil.

Method of sub-soil Exploration

① Direct Method (Test pits & trenches)
② semi-direct Method (Bore holes)
  ⓐ Augur boring → Suitable for almost all types of soil except rocks at shallow depth.
  ⓑ Wash boring → Suitable for all types of soil except rocks.
  ⓒ percussion drilling → Suitable for all types of rock including soft rocks.
  ⓓ Rotary drilling → Suitable for all types of rock, including hard rocks.
③ Indirect Method (Geophysical method of sounding)

Sampling

Process of obtaining soil sample from site:

Types of Sample

① Disturbed Sample	Undisturbed Sample
→ Equipment : split spoon sampler.	→ Thin walled sampler.
→ Type of soil : Cohesionless (Sandy) soil	→ Cohesive (Clay) soil.

Objectives of Foundations

→ To evenly distributes the super structure load to the sub soil.
→ To provide level surface structure to rest.
→ To provide lateral stability.
→ To protect against soil movement.

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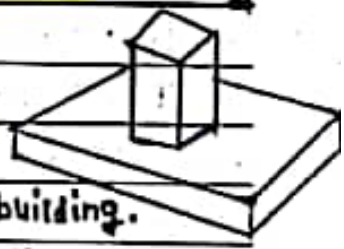
Types of Foundation

(A) Shallow Foundation	(B) Deep Foundation
→ Depth of foundation is less then or equal to Width of foundation.	→ Depth of foundation is greater then Width of foundation.
i.e; $D_f \leq B$	i.e; $D_f > B$
→ Transfer load on lesser depth.	→ Transfer load on greater depth.
→ Construction materials are easily available.	→ Construction materials are not easily available.
→ It transfers load by end bearing only.	→ It transfers load by end bearing & skin friction.
→ Construction process is simple.	→ Construction process is complex.
→ Cost of construction is less & takes less time.	→ Cost of construction is more & takes more time

Types of Shallow Foundation



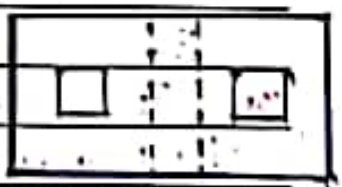
① Isolated / Individual / pad footing

→ Most common type of foundation used in building.

→ Constructed for a single column. → $\frac{\text{length}}{\text{breadth}} = 1-2$

→ Square or rectangular in shape.

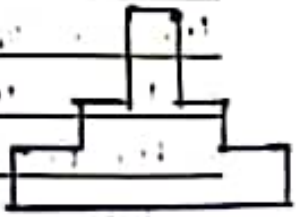
→ Also called spread footing.



② Combined Footing

→ It support two or more column.

→ Two columns are close to each other & their isolated footings overlap each other. → Rectangular in shape.



③ Strip / Wall footing

→ Length of footing is very greater then width.

→ It supports load bearing wall.

④ Strap footing

→ Two isolated footing are connected by strap beam.

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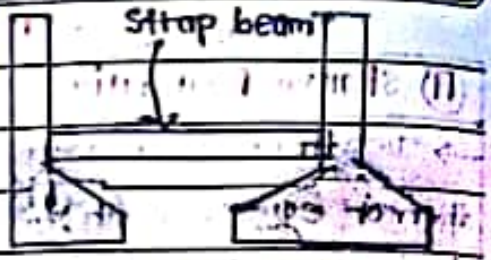
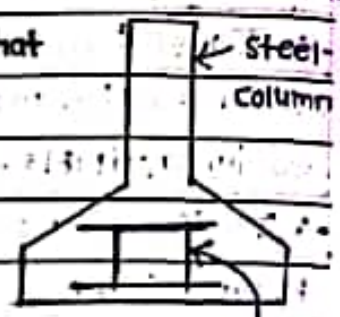
→ The distance between the column is large, strap footing is provided.

→ Used near property line, eccentric loading.



⑤ Grillage footing

→ It is a special type of isolated footing that used in case of heavy loaded steel column.



⑥ Mat/Raft Foundation

It is a flat concrete slab, heavily reinforced with steel that support the walls & columns of the entire structure.

Suitability

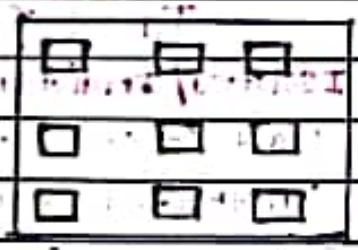
→ if isolated footing covers more than 50% of entire area of the structure.

→ Heavy load is expected.

→ Soil having low bearing capacity.

→ Chances differential settlement.

→ for expansive soil, like black cotton soil.



Types of Deep Foundations

① Pier Foundation

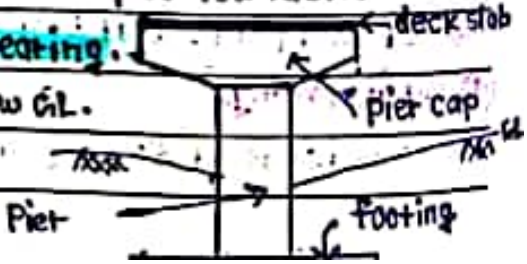
→ It Consists of cylindrical column of large diameter to transfer superimposed loads to firm strata below.

→ May be made up of masonry or reinforced concrete.

→ pier foundation shallower in depth then pile foundation.

→ Transfers load only through end bearing.

→ if good bearing strata exists 5m below GL.



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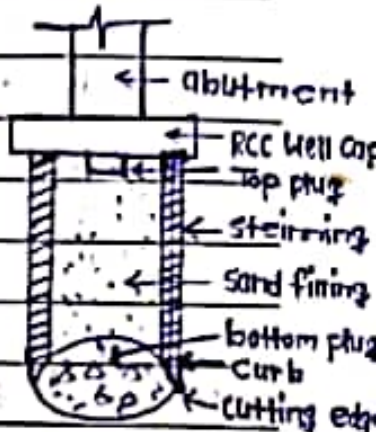
② Well / Caisson Foundation



→ It consists of single large diameter well or smaller wells of circular or other shapes.

→ It is built above the ground level & then sunker into the ground.

→ Large x-section then piers.

→ Transfer heavy load.

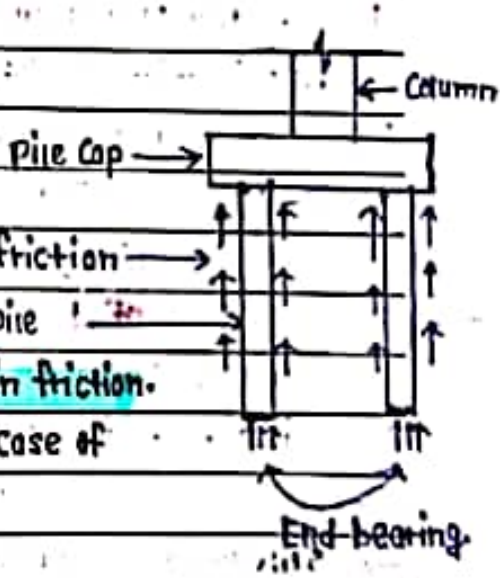
→ Used in major foundation work such as bridges, piers, abutment in rivers / lakes etc.

→ Types: Circular, Square, rectangular, double D.

→ Box, open, monolithic

Note: Simple in construction & sinking

③ Pile Foundation



→ It transfer heavy loads from the structure to greater depth below ground level.

→ Made up of Wood, Steel, Concrete.

→ Transfer load through end bearing & skin friction.

→ Used in case of water logged soils in case of bridges, multi-storey building etc.

Suitability

→ When load of superstructure is heavy & it's distribution is uneven.

→ if water table is high & the soil is compressible.

→ The soil has low bearing capacity. → In marine structure.

→ To ensure stability & durability.

→ When structure is situated near water bodies.

Types End bearing pile, friction pile, archer pile, sheet piles etc.

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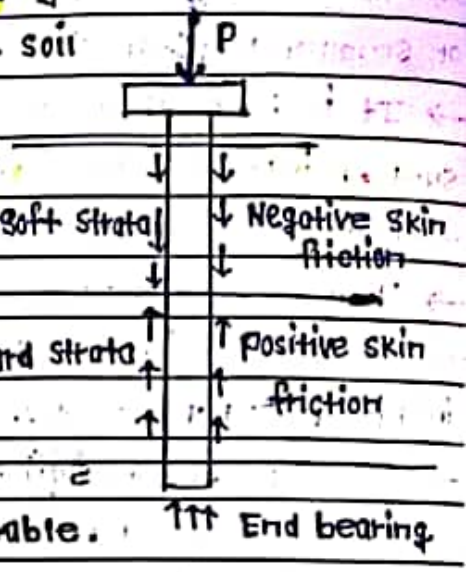
Negative Skin Friction

It is the downward friction force generated due to downward movement of surrounding soil relative to piles.

→ It is also called downdrag.



Causes of Negative Skin Friction

→ Soft soil strata followed by hard strata.

→ Application of surcharge to site.

→ Sudden lowering of ground water table.

Remedial measures for Negative Skin Friction

→ Application of lubricants such as oil or grease can reduce the friction between surface.

→ Use of slender columns of small diameter.

Causes of Foundation Failure

→ Result of sub-soil exploration of foundation failure.

→ Differential settlement of structure.

→ " " " sub-soil.

→ Swelling & shrinkage of sub-soil strata.

→ Seismic effects.

→ Penetration of roots of trees within foundation.

Minimum Depth of Foundation

By Rankines

$$D_{min} = \frac{q}{\gamma}\left[\frac{1-\sin\phi}{1+\sin\phi}\right]^2$$

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Where; D_{min} = minimum depth of foundation.

q = Intensity of loading at base of footing

γ = Unit Wt. of soil

ϕ = angle of repose of soil.

Note: In practice the minimum depth of foundation should be 1m or base as firm soil.

→ minimum depth of footing for load bearing wall = 90cm.

Shoring

Shoring is the construction of temporary structure to support temporarily an unsafe structure.

Objective of Shoring

→ Defective parts of building are to be dismantled & rebuilt.

→ Support upper part of wall during formation of large opening on the walls. → Intermediate building is to be dismantled.

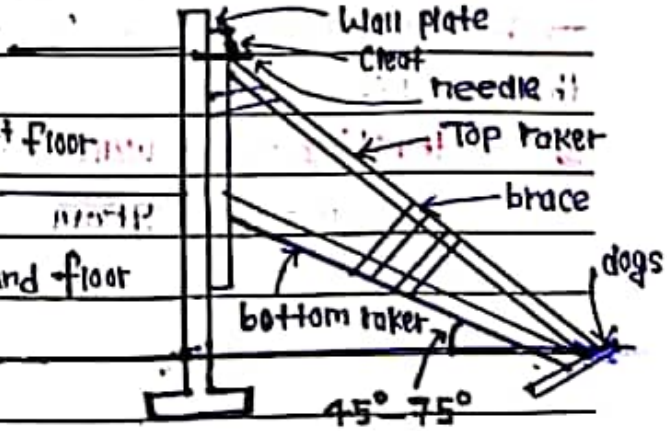
→ Avoid failure of structure where removing adjoining structure.

Types of Shoring

① Raking shoring

→ Inclined members known as rakers are used to provide lateral support to wall.

→ inclined at 45°–75°



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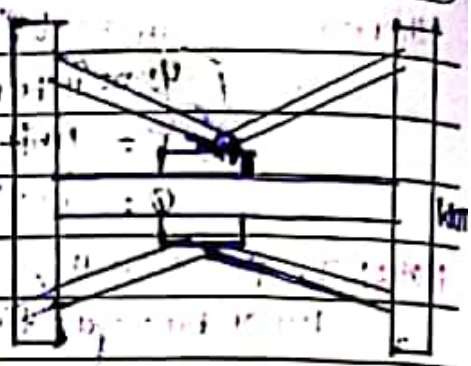
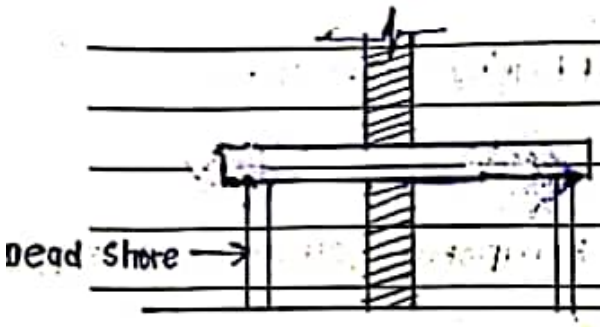
② Fly / horizontal Shoring

→ horizonta support is providedin to unsafe structure.



③ Dead Shoring

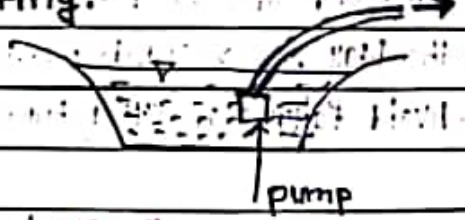
→ Vertical support provided to Wans to create an opening.



Dewatering

The process of removal of surface or ground water from construction site is dewatering.

→ Usuany carried out by pumps.



Method of Dewatering

① Open sump pumping

→ Using pumps. → Simplest, chepest & most effective.

② Well point system

→ Wells drilled around construction. & pumps are place into these wells.

③ Constructing Deep Wells.

→ Large quantity of groundwater is required to be removed.

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Design of Brick/Stone masonry Foundation

Thickness of brick wall, $T = \frac{W}{P \times L}$

Where: W = Weight of the wall

P = Allowable compressive strength

L = Length of Wall

Depth of Concrete block (below masonry wall) $d = a\sqrt{\frac{3q}{m}}$.

Where, d = Depth in cm

a = Maximum projection beyond the masonry in cm.

q = Net soil bearing (kg/cm^2)

m = Safe modulus of rupture of Concrete (kg/cm^2).

Walls

Wall is a vertical member of structure used to divide or enclose in building construction.

Types of Wall

① Load Bearing Wall

→ The Wall which is design to carry superimposed load in addition to its self weight is called load bearing Wall. These Walls supports structural member such as beam, slab, roof etc.

Types of load bearing Wall

① Masonry Wall

② Stone Wall → Thickness (350mm) Minimum

③ brick Wall → Thickness (230mm)

④ Retaining Wall

⑤ precast Concrete Wall

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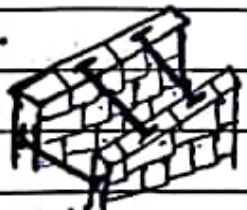
① Solid masonry → Most common wall in which individual blocks such as brick or stones are used in horizontal course with suitable mortar. → Constructed without any voids.

② Cavity Wall → It is constructed in two leaves with a cavity / gap between them & are tied together with metal ties.
→ Two leaves act as one structural unit. → Air gap
→ Horizontal & Vertical spacing of ties ≯ 900mm & 450mm.
→ It is design to carry axial load & bending.
→ Also known as twin skin or hollow wall.
→ Size of Cavity Wall = 4 – 10cm.
→ purpose of Cavity Wall ① heat & sound insulation.
② Damp proofing
③ Reduce self weight.



③ Faced Wall - Faced Wall has the facing & backing of two different materials are bonded together to ensure common action under load.

④ Veneered Wall → single non-structural external masonry wall made of brick, stone.

② Non Load Bearing Wall
→ The Wall which is design to carry self load only is called non-load bearing wall. & do not support any structural member.
→ It is known as interior wall.

Types of Non load bearing Wall

① Party Wall A wall separating the adjoining building.
→ Example; compound Wall.

② Panel Wall → commonly related to framed structure.
→ Generally made of Wood.

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© Partition Wall → A thin internal wall, to divide the large space into rooms. These walls are made up of glass, fiber boards, brick masonry etc.

(d) Separating Wall → A wall separating different occupancy within the same building is called separating wall.

(e) Curtain Wall → A self supporting wall carrying no othe vertical loads but subjected to lateral loads, it is designed to carry Wind load & self Weight.

Slenderness Ratio

The slenderness ratio of a masonry wall is defined as the effective length or height divided by the effective thickness, whichever is less.

$$\text{Slenderness ratio} = \frac{l_{eff}}{t_{eff}} \text{ or } \frac{h_{eff}}{t_{eff}}$$

→ Maximum permissible slenderness ratio

= 27 for load bearing wall

= 30 for non-load bearing wall

Masonry

→ Masonry unit bonded with mortar is called masonry.

→ masonry unit are; stones, bricks, Concrete block etc.

Stone Masonry

→ Stone bonded with mortar is called Stone masonry.

→ minimum thickness of stone masonry = 350mm

→ mortar thickness = 20mm

Types of stone masonry

A Rubble Masonry.

→ In rubble masonry, the blocks of stones that are used are either undressed or comparatively roughly dressed.

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→ Wide joints of stones of irregular size are used.

① Random Rubble

(a) Un-Coursed : → It is the roughest & cheapest.

→ Stones are not of uniform shape & size.

(b) Built to Coursed : → It is similar to un-coursed except that the work is roughly level upto form courses 30-45 cm. thick.

② Square Rubble

(a) Un-Coursed : → Stones having straight beds & sides are arranged in an irregular pattern to give a good appearance.

→ Avoid the formation of long, continous joints.

(b) Built to Coursed → Stones having straight bed & sides are leveled up to form courses of varying depth.

(c) Regular Course → Stones having straight beds & sides are leveled up to form courses of varying depth but the height of stones in each course is the same.

③ Dry Rubble

→ Mortar is not used in joints.

→ Chepest but more skilled manpower is required in Construction

→ For non-load bearing wall like Compound wall.

B Ashlar masonry

In ashlar masonry, square & rectangular blocks that are dressed & have an extremely fine bed & end joints.

① Ashlar fine tooled

→ It is the finest stone masonry.

→ The bed, joints & face of the stones are chisel dressed to remove all uneveness & obtain perfectly horizontal & vertical joints.

② Ashlar rough tooled

→ The beds & sides are finely chisel dressed but exposed thru face is dressed by rough tooling.

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③ Ashlar rock faced

→ The exposed face of the stones is not dressed but is kept as such to give rough facing.

④ Ashlar Chamfered

→ It is a special type of ashlar rock-faced.

→ Strip provided around the perimeter of the exposed face is chamfered at an angle of 45° to a depth 25mm.

⑤ Ashlar block in Course

→ It is immediate between ashlar & rubble masonry.

→ Face of each stone are hammer dressed but the vertical joints are not a straight & fine, as in ashlar masonry.

⑥ Ashlar facing

→ It is provided along with brick or concrete blocks to give better appearance.

→ The outer face of the stones are rough tooled & chamfered.

Bond

In masonry, systematic arrangement of bricks or other building units composing a wall or structure in such a way as to ensure its stability & stren

Types of Bond

① Stretcher Bond

→ Also called running bond. → Bricks are laid as stretcher on the face of the wall. → Used only for single or half brick wall → partition wall.

② Header Bond

→ Bricks are laid as header on the face of the wall.

→ Used for the construction of walls with full brick thickness.

③ English Bond

→ It has two alternating courses of stretcher & headers.

→ It is strongest type of bond.

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④ Flemish Bond

→ A flemish bond pattern consists of each course of alternate headers & stretchers.

Terminology.

① Attrise → Edge of brick. → in good quality brick; straight & sharp

② Bat → portion of brick cut across the width.

→ It is also known as Closer.

③ Bull nose → It is a special moulded brick with one edge rounded or both end rounded. → ① single & ② double bull nose.

④ Bed → Lower surface of brick or stone.

⑤ Bond → over-lapping of bricks/stone in alternate course so that no continuous vertical joints.

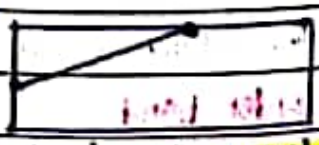
⑥ Cladding → Application of one material over another to provide a skin or layer. → Used to provide a degree of thermal insulation, weather resistance & improve appearance of building.

⑦ Closer → It is a portion of brick which is so cut that the one long face remains uncut.

Types ⓐ King Closer → It is the portion of brick which is so cut that the width of one it's end is half that of full brick while the width at the other end is equal to full width.

→ Obtained by cutting the triangular piece between the center of one end & center of other end.

→ It has half header & half stretcher face.



ⓑ Queen Closer → It is the portion of brick obtained by cutting a brick lengthwise into two portion.

ⓒ Bevelled closer → special form of king closer.

→ Whole length of brick is beveled in such a way that half width is maintained at one end & full width is maintained at other end.

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⑦ Mitred Closer → It is a brick where end is cut sloped (45° – 60°) for full width. → The one layer face of mitred closer is of full lengt while other longer face is smaller then length.

⑧ Cow nose → It is a special moulded brick with one edge via length or both end via length is rounded.

⑨ Course → It is a horizontal layer of masonry unit laid on same bed → Thickness = brick thickness + one mortar joint.

⑩ Corbel → It is a projecting stone which is usually provided to ser as support for truss etc.

⑪ Cornice → It is a projecting ornamental course near the top of the wall or at the junction of wall & the ceiling.

⑫ FAR → Ratio of total covered area on all floors & area of plot.

⑬ Frog → It is the depression on the surface of brick.

⑭ Frieze → It is the course of stone placed immediately below the cornice, along the face of wall.

⑮ Fresco → It is in painting, the technique of applying water-based pigment to wet or fresh lime mortar or plaster.

⑯ Lap → Horizontal distance betn vertical joints of successive brick cours

⑰ Mould → Hollow container used to give shape.

⑱ pier & pilaster → Pier is a isolated vertical mass of stone/brick masonry to support beam, lintel, arches etc. the width of which exceeds four times it's thickness.

→ If it has a projection beyond the support the end of beam etc, then it is called pilaster.

⑲ Quoin → It is a corner or external angle on the face side of wa

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Orientation of Brick

① Stretcher → Brick laid flat with its long narrow side exposed.

② Header → Brick laid flat with its width exposed.

③ Shiner → Brick laid on the long narro side with the broad face of the brick exposed.

④ Sailor → Brick laid vertically with the broad face of brick exposed.

⑤ Soldier → Brick laid Vertically with its long narrow side exposed.

⑥ Rowlock → Brick laid on the long narrow side with the short end of the brick exposed.

Tools used in masonry work

① Brush	→ Cleaning.
② Brick hammer	→ Cutting brick
③ Bubble tube	→ To check horizontality or verticality of wall/floor.
④ Crow bar	→ Dressing surface of stone.
⑤ Hand saw	→ To Cut soft stones.
⑥ Floating rule	→ Finishing.
⑦ Iron hammer	→ For Carving.
⑧ Lines & pins	→ for correct alignment.
⑨ Mallet	→ Wood hammer.
⑩ Mason Square	→ To set out right angle.
⑪ plumb rule	→ To check Vertical of Wall.
⑫ square	→ Checking perpendicularity.

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(13) scutch	→ for dressing & cutting the brick.
(14) shovel/ spade	→ Excavation, mixing etc.
(15) spall hammer	→ Rough dressing.
(16) scabbling "	→ for breaking stone.
(17) Trowel	→ lifting, throwing, spreading the mortar.
(18) Tri-Square	→ Right angle.
(19) Water level	→ To transfer level & Check level.
(20) Mortan pan	→ To carry construction material.

Dampness

The presence of unwanted water particles on the surface of materials inside the building components is known as dampness.

→ It ultimately reduces the strength & durability of the building.

Causes of Dampness

→ Rising of moisture from the ground.
→ From the external wall.
→ Rain travel from wall top.
→ Poor drainage, defective construction, imperfect roof slope.
→ Gravitational water.
→ Hygroscopic water.

Effect of Dampness

→ Rise to breeding of moisquito & Creates unhealthy hygienic condition.
→ Effecting the decoration.
→ Efflorescence effect on wall.
→ Timber fitting likes door, windows etc. get deteriorated.
→ Electrical fitting get deteriorated.
→ Softening & Crumbling of plaster.
→ It promotes the growth of termites.
→ Rusting & Corrosion of metal fittings.

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Damp proofing Course (DPC)

The layer of certain materials used to prevent the dampness is called damp proofing course.

→ Provided 15 cm above the GL.

→ It is provided in horizontal as well as vertical portion of wall.

→ DPC is made of 1:2:4

→ Thickness of DPC = 40mm

Remedial Methods of Damp proofing

① Membrane damp proofing

→ Introducing a water repellent membrane or DPC bet^n the source of dampness & part of building adjacent to it.

→ DPC may be flexible material (bitumen, mastic asphalt, bituminous felts) or metal sheet, polythene sheet etc.

② Integral damp proofing

→ Introducing a certain water proofing materials (chalk, talc, soap, petroleum, oil etc) to the concrete mix.

③ Surface treatment

→ Application of layer of water repellent substance or compounds on these surface through which moisture enters.

④ Cavity Wall

→ Effective method of damp prevention.

→ Main Wall of building is shielded by an outer skin wall; leaving a cavity between the two.

⑤ Guniting

→ It is the process of providing impervious layer of rich cement mortar over the exposed surfaces under pressure.

→ The rich mortar consists of cement : sand (1:2 to 1:3) & pressure is given 2–3 kg/cm².

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→ The nozzle of the machine is kept at a distance of about 1m (75 - 100 cm) from the surface to be gunited.

⑥ Pressure grouting.

→ It is the process of providing cement grouted under pressure into cracks, voids, fissures etc

→ It is also known as jet grouting.

Temporary Construction

A Formwork

→ Temporary construction used as a mould for structure, in which concrete is placed & hardens & matures.

→ Materials : local wood, plywood, steel, aluminum, plastic etc.

→ Comprises 20 - 25 % of concrete cost.

Requirement of a Good Formwork

→ Should be strong enough to with stand all type of dead & live load.

→ Joints of formwork should be water tight.

→ Should be suitable for reuse.

→ Should be cheap & easily available.

→ Should be light in weight.

→ Should be water proof.

Stripping → process of removing the formwork.

Sequence of stripping) Vertical member → slab → beam.

* Vertical member (column, walls) → 1-2 days.

* slab → (span ≤ 4.5m) : 7 days → (span > 4.5m) : 14 days.

* Beam → (span ≤ 6m) : 14 days → (span > 6 m) : 21 days.

Note: → Steel formwork can used upto 50 times & timber formwork can used upto 5 times only.

→ min^m & max^m C/C spacing of props = 1 & 1.8m respectively

→ Most suitable wood for form work → well seasoned soft wood.

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[B] Underpinning

The process of placing a new foundation over an existing foundation is called underpinning.

Methods ① pit underpinning ② pier underpinning ③ pile underpinning

[C] Scaffolding.

Scaffolding is a temporary structure to support the original structure as well as workmen used it as a platform to carry on the Constructions works.

→ Height of building exceeds 1.5 m, scaffolding is needed.

Uses of Scaffolding

→ platform for workmen
→ Temporary storage of material
→ Efficient working
→ for safety.

Types of scaffolding

① Single scaffolding
② Double scaffolding
③ Steel scaffolding
④ Cantilever scaffolding
⑤ Trestle scaffolding
⑥ Suspended scaffolding.

Concrete Technology

An artificial stone that is made up by mixing cement, sand, aggregates, water & admixtures etc in specific proportions is called Concrete.

→ Concrete is the heterogeneous, multiphase material which is composed of binding material, inert filler & water that hardens over time.

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Advantage of Concrete

→ High Compressive Strength.
→ Durability is high.
→ Moulded into desired shape
→ Fire proof.
→ Ingredients of concrete are easily available.
→ Casting of concrete can be done at site that makes it economic

Disadvantage of Concrete

→ Very low tensile strength. (10 % of compressive strength)
→ Reinforcement must be provided to improve its tensile strength.
→ Weight of Concrete is high as compared to its strength.
→ Soluble salts in cement cause efflorescence.

Type of Concrete

A Based on Design
① plain cement concrete (PCC)
② Reinforced Cement Concrete (RCC)

B Based on purpose
① Light Weight Concrete
② Heavy Weight Concrete
③ Fiber reinforced concrete
④ Vacuum Concrete.
⑤ Fire resistance Concrete.

Constituents / Ingredients of Concrete.

① Cement
② Sand (Fine aggregate)
③ Coarse aggregate
④ Water
⑤ Admixtures (optional)

Water → It is essential ingredients of Concrete.
→ Act as a lubricant for fine aggregate & Coarse aggregate.
→ Used for curing.
Qualities → PH value : 6 – 8 → Free from organic matter.
→ Should be pure as possible
→ sea water is avoided.

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Water Cement Ratio (W/C)

→ It is the ratio of Volume of water to Volume of cement or weight of water to weight of cement used in concrete mix.

→ W/C ratio by weight more compared to by Volume.

→ Generally expressed in liters of water per bag of cement.

* According to Mr. power, W/C ratio less then 0.4 may not be sufficient to complete hydration.

Grade	W/C Ratio	
	PCC	RCC
M_{10}	0.65	
M_{15}	0.60	
M_{20}	0.45-0.5	0.55
M_{25}	0.40	0.50
M_{30}		0.45
M_{35}		0.45
M_{40}		0.40

According to IS456 : 2000 (4th Amendment)

→ Standard grade of concrete – 8

→ Total grade of concrete – 19

Abhram's W/C Ratio Law

→ For any given condition test, strength of well compacted concrete with good workability depends on W/C ratio.

* Strength of concrete is inversely proportional to W/C ratio.
* " " " " directly " " C/W ratio.

MCQ : ① If W/C ratio for concrete is 0.60, then water required for one bag of cement is. → $W/C = 0.60$; 1 bag Cement = 50kg

$\therefore W = 0.60 \times 50 = 30kg$ *

② Strength of cement : With passage of time → Decrease

③ " " Concrete. " " " " → Increase

Factor Affecting Strength of Concrete

→ **W/C ratio** : Strength of Concrete, decrease with increase W/C ratio.

→ **Size of aggregate** : Strength of Concrete increase with increase in size of aggregate in some extent.

→ **Shape of aggregate** : Angular aggregate has more bonding strength

→ **Type of cement** : RHPC has higher early strength then OPC.

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→ **Age** : Strength of concrete increase with increase in time with decrease rate.

→ **Curing** : strength of concrete is higher in use of water curing then air curing.

Days	1	3	7	14	28	90	180	360
% strength	16	40	65	90	100	115	120	130

Manufacture of Concrete

① **Batching** → The process of measurement of concrete ingredients with required proportion.

Types ① Volume Batching → Measurement is done by volume.

→ Use of gauge box (35 cm × 25 cm × 40 cm). ≈ 35 liters

→ Done for nominal mix of concrete.

→ Less accurate then weight batching.

② Weight Batching → Measurement is done by weight.

→ Done for design mix of concrete.

→ more accurate then volume batching.

② **Mixing** → Mixing is done until there is uniform distribution of material & mass of uniform colour & consistency.

→ If there is segregation after unloading from the mixer, the concrete should be remixed.

Types ① Hand mixing (Manual mixing)

→ Mixing is done using hand by workmen.

→ Required 10% extra cement.

→ Suitable for smaller quantity of concrete for minor works.

② Machine mixing (Mechanical mixing)

→ Mixing is done using mixer machine.

→ No. of revolutions of drum per minute = 25–30.

→ Mixing time of concrete = 2–3 minutes.

→ Time of mixing also depends on capacity of mixer.

Note : The process of applying cement & water to the drum before mixing of constituents of concrete is called buttering.

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③ Transporting → Concrete should be transported to the place of deposition. method of transporting : pan, wheel barrow, truck, dumper, belt conveyors, pumping, chute & spillways etc.
→ pumping can transport concrete 400 m horizontally & 90m vertically.

④ placing → Maximum height of pouring of concrete without segregation = 1.5m.

⑤ Compaction → process of removal of entrapped air from fresh concrete.
→ use of vibrators ÷ generally used needle Vibrator.

⑥ Finishing → operation adopted for obtaining a true & uniform surface is called finishing. Finishing operation

ⓐ screeding → It is the levelling operation which removes the bumps & hollows & give a uniform surface.

ⓑ Floating → It is the operation of removal of irregularities from surface of concrete left after screeding.

ⓒ Trowelling → Final operation of Concrete finishing using trowel.

Curing

The process of preventing loss of moisture from concrete while maintaining a satisfactory temperature condition is called curing.

Objective / Importance of Curing

→ keep the concrete saturated.
→ Reduce shrinkage.
→ preserve properties of concrete.
→ prevent loss of water by evaporation.
→ Control temperature of Concrete.
→ Increase strength & durability of Concrete.

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Minimum Curing Time for Different Construction

Constitution Type/ Cement Type	Curing period (days)
① ordinary portland cement	7
② Reinforced mass concrete	7
③ Coloured Concrete floors & slabs,	7
④ Shotcrete Concrete	7
⑤ Concrete exposed to dry & hot weather	10
⑥ Unreinforced mass section	14
⑦ Cold places	28

Methods of Curing

① Water curing → Best method of curing.

② Immersion → Used for pre-cast Concrete member.
→ Best method of curing.

ⓑ ponding → for horizontal members (slab, road pavements etc.)

ⓒ Spraying → for vertical/ sloping member (Wall, Columns etc)

② Membrane Curing → Covering Concrete surface with materials like jute bag, cement bag etc.

③ Steam Curing → Used in Cold Weather.
→ Suitable for pre-cast Concrete member.
→ Not used with high alumina cement.

④ Chemical Curing → NaCl, $CaCl_2$ (नून) etc are used where there is scarcity of water.

Workability

It is the property of fresh concrete which determines the amount of internal work necessary for full compaction.

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Factors affecting Workability of Concrete

1. **Water content (W/C ratio) :** Workability is directly proportional to W/C ratio.
2. **Mix proportion :** Workability $\propto$ Rich mix & Workability $\propto \frac{1}{\text{Lean mix}}$
3. **Size of aggregate:** Workability $\propto$ size of aggregate.
4. **Shape of aggregate:** Rounded aggregate has higher workability.
5. **Grading of aggregate :** Well graded aggregate provide better
6. **Time of transit:** Workability is decrease with increase in time of transit.
7. **Surface texture:** Rough textured aggregate will show poor workability then smooth & glossy aggregate.

Tests on Workability

1. **Slump test**

→ **Determine consistency** of concrete.

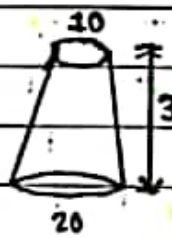
→ It is simple to understand & easy to perform.

→ **Field test as well as lab test**

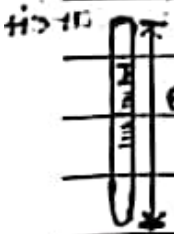
→ Suitable for medium to high workability.

Apparatus

1. Cone of frustum
2. Tempering rod



Size = 10cm x 20cm x 30cm (TBH)



Length – 60 cm

Diameter – 16 mm.

Procedure

→ Place the slump mould on a smooth, flat & rigid surface.

→ mix the dry ingredients of concrete thoroughly & then add the required quantity of water.

→ **Fill the cone in three equal layers.**

→ **Compact each layer of concrete 25 times.**

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→ Remove the mould immediately & vertically.

→ measure the subsidence of Concrete from top with help of scale

② C.F test (Compacting factor test) → Lab test.

→ It is more precise & sensitive then slump test.

→ particularly used for Concrete mixes of low workability.

$$C.F. = \frac{\text{wt of partially compacted concrete in a cylinder}}{\text{wt of fully compacted concrete in a cylinder}}$$

③ Flow-table test → field method

④ Kelly ball test

⑤ Vee-bee consistometer test → Laboratory method.

Workobility	Very low	Low	medium	High
Slump test (mm)	0–25	25–50	50–75	>75
CF test	<0.85	0.85–0.92	0.92–0.95	>0.95
Vee-bee test (seconds)	10–20	5–10	2–5	0–2

Note :

minimum no of test specimen for compressive strength test = 3

" " " " " " tensile " " = 6

" " " " " " Compressive strength of brick = 5

Concrete Mixes

Mix Design → The process of selecting suitable ingredients of Concrete & determining their relative proportions with the objec of producing Concrete of minimum strength & durability as economically as possible.

Nominal mix	Design mix
→ All ingredients are prescribed & proportion or specified. & no any deviation by designer.	→ The choice of ingredients & proportioning are left to the designer to be decided

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→ Measured in Volume basis.	→ Measured in Weight basis.
→ No quality control.	→ Quality control.
→ Used in ordinary concrete.	→ Adopted for high grade concrete
Grade not higher then M20.	
→ Easy to design & prepare.	→ prepared for different environmental conditions.
→ W/C ratio is based on durability Critera, experience & practical trails	→ W/C ratio is based on concrete grade, durability & 28 days strength of concrete.

Grading of Aggregates

→ It is the process of mixing different size of aggregate to minimize the voids & makes the concrete economical.

→ Grading of aggregate is the particle size distribution, which is determined by sieve analysis.

Grades of Concrete

S.N	Grade	Concrete mix	Characteristics Strength (N/mm^2)	Remarks
1.	M5	1:5:10	5	
2.	M7.5	1:4:8	7.5	
3.	M10	1:3:6	10	Ordinary Concrete
4.	M15	1:2:4	15	
5.	M20	1:1.5:3	20	
6.	M25	1:1:2	25	
7.	M30		30	
8.	M35		35	Standard Concrete
9.	M40		40	
10.	M45		45	

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11.	M50		50	
12.	M55		55	
13.	M60		60	
14.	M65		65	
15.	M70		70	
16.	M75		75	
17.	M80		80	

Flooring & Finishing

Floor : Floors are the horizontal elements of a building structur which divide the building into different level for the purpose of creating more accommodation (आवास).

Requirements of floors in buildings.

→ Strength & stability. → Durability
→ Fire resistance → Free from maintenance.
→ Resistance to passage of heat & sound.
→ Resistance to weather & ground moisture.

Materials used for flooring

① Brick flooring → Used in warehouse, stores & godowns etc.
→ Bricks are laid on flat or an edge & arranged in good looking pattern
Merits → Durable & sufficiently hard.
→ Cheaper then cement concrete, Wooden & mosaic flooring.
→ It is non-slippery → It is easily repairable.
Demerits → It is absorbent.

② Concrete flooring → Used in residential, commercial, industrial build
→ flat slab is formed of concrete, either poured in-situ or pre-cast.
Merits → Can be designed for any budget.
→ Unlimited creative options. → Required little maintenance.

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→ Resists moisture. → Will last for decades (50+ years)

Demerits → Can be difficult to patch. (area)

→ Cracks or develop over time

→ Can become slippery when wet.

③ Flag stone flooring → Used in store, courtyard, public places.

→ Covered by square or rectangular flagstone slab.

→ Another form of sand stone.

→ 20 – 40 mm thick sand stone are used.

merits → very economical where stone is easily available.

→ Maintenance is easy & cheap.

→ It is hard, durable & wear-resistant.

Demerits → Not very fine & smooth.

→ Not very impervious.

④ Terrazzo flooring → Used in residential, school, office & hospitals building etc.

→ Made with marble chips of size 3mm – 6mm.

⑤ Mosaic Flooring → Used in operation theatre, temples, bathroom.

→ Made of small pieces of broken tiles of china glazed or marble chips of size 1.5 mm – 3mm.

⑥ Timber flooring → Dancing Hall, auditorium etc.

⑦ Asphat flooring → Swimming pools. (non-slippery nature)

⑧ Cork flooring → Church, libraries, theatres etc.

⑨ Rubber flooring → Hospital, x-ray room & radio station.

⑩ Granolithic flooring → Used in industrial building.

→ Made of cement, sand & very hard tough quality aggregate such as granite.

⑪ Marble flooring → Bathroom, Kitchen, Hospital etc.

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Plastering

Plastering is the process of covering rough walls or uneven surface by mixture of C/S mortar.

→ The coating of plastering on external exposed surface is known as rendering.

Objective of plastering

→ To give good look.
→ To improve appearance of structure.
→ To give smooth surface to avoid catching of dust.
→ To protect the wall from rain water & other atm agencies.
→ To conceal defective workmanship.

Requirements of Good plaster

→ It should be cheap & economical.
→ It should be hard & durable.
→ It should be possible to apply it during all weather conditions.
→ It should possess good workability.
→ It should effectively check the entry of moisture from surface.

Plaster Ratio

S.N	Component	Ratio (C:S)
1.	Brick Work (≥ 230 mm thick)	1:6
2.	Brick Work (≤ 115 mm thick)	1:4
3.	Internal plaster	1:5
4.	External plaster	1:4
5.	Ceiling	1:3

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Term used in plastering Works

① Back ground → Surface to which first coat of plaster is applied. →(परवलि)

② Blistering → Development of local swellings on the finished plastered surface due to residual unslaked lime.

③ Cracking → Development of one or more fissures in plaster due to movement in the background.

④ Crazing → Development of hair cracks usually in an irregular pattern over finished surface. (सामे crack)

⑤ Dado → Lower part of plastered wall, where special treatment is given to make it better resistant.

⑥ Dubbing Coat/out → process of filling up hollow spaces in solid background, before applying main body of plaster.

⑦ Flaking → process of scaling away patches of plaster of previous coat due to lack of adhesion with under coat. (पत्र उतरना)

⑧ Hacking → The process of making the back ground rough to have suitable key for plastering.

⑨ Gauging → The process of mixing the various ingredients of plaster.

⑩ Peeling → Removal of plaster from background.

Plastering Tool

① Float → This is used to spread the mortar on the required surface. → Used for surface of wall. → It can be metal or wood.

② Floating Rule → It is used for checking the level of the plastered surface between successive screens.

③ Gauging Trowel → This is used for applying mortar & for trowelling so as to obtain finish. it has a pointed nose top.

④ Plumb bob → It is used for vertically of the plaster.

⑤ Brushes, bubble tube, set square, straight edge etc.

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Types of plaster

Mortar is a bonding agent which is generally produced by mixing cementing or binding material (cement or lime) & fine aggregate (sand, surki, sawdust etc) with water.

Types of Mortar

① cement mortar → cement is used as binding material.
→ Sand is used as fine aggregate.

② Lime mortar → Lime is used as binding material.
→ Sand is used as fine aggregate.

③ Gauged mortar → cement & lime both are used as binding materia
→ Sand is used as fine aggregate.
→ It is suitable for water logged area.
→ The cement to lime proportion varies from 1:6 to 1:9.
→ Economical then cement concrete.
→ Higher strength then lime mortar.

④ Surkhi mortar → Lime is used as binding material.
→ Surki is used as fine aggregate.

⑤ Mud mortar → Mud is used as binding material.
→ Sawdust, rice husk or cow-dung is used as fine aggregate.
→ Useful where cement or lime is not available.

punning

→ punning is the process of applying cement paste on a plastere surface to make it smooth & durable.
→ Quantity of cement required = 1kg/m² or (1:1 - cement : Sand)
→ Thickness of punning = 3mm generally
→ Measured in sqm.

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pointing

→ The process in which masonry joints are filled up with rich mortar (1:2 – 1:3) after raking out for small depth. → It protects joints from water.

→ For better appearance → measured in sqm.

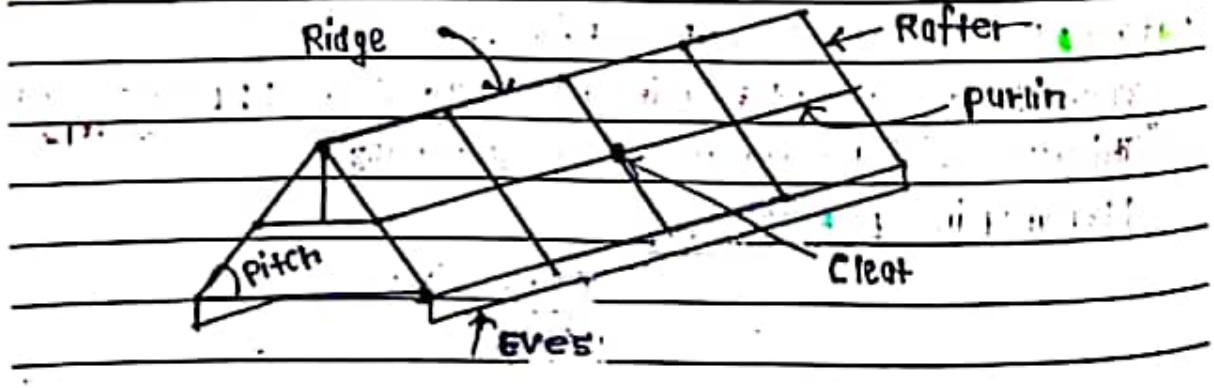
Types of pointing

① Flush pointing ② Struck pointing ③ Weathered pointing

④ V-grooved pointing ⑤ Beaded pointing ⑥ Keyed pointing

⑦ Tuck pointing

Truss



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Terms in Truss

① cleat → piece of wood or metal which is placed on rafters of trusses to support the purlin.

② pitch → slope of truss with horizontal.

③ purlin → Horizontal member running along length.

④ Rafter → Inclined member apart from ridge to eves.
→ supports covering materials.

⑤ Hip → The line of inclination of sloping surface of slope roof having internal inclination less then 180°.

⑥ Valley → The line of inclination of sloping surface of slope roof having internal inclination greater then 180°.

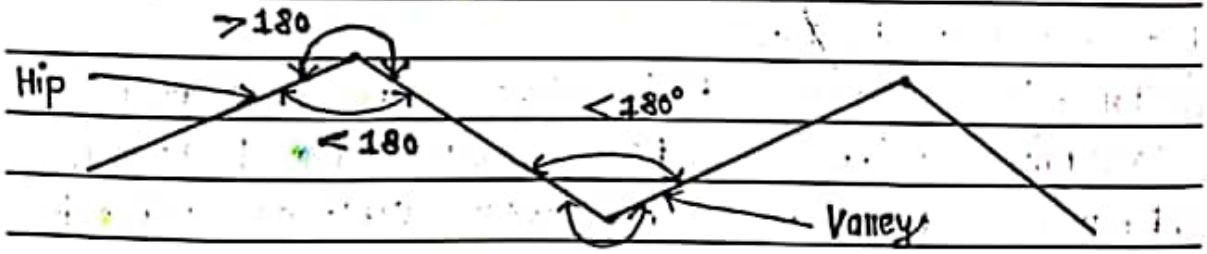
⑦ Ridge → Apex line of sloping roof.
→ The beam provided along the ridge is known as ridge beam.

⑧ Eves → Low edge of inclined roof surface.

⑨ Gable → Triangular upper part of wall formed at the end of pitched roof.

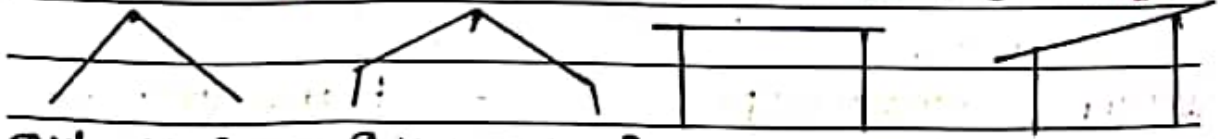
⑩ Rise → Vertical distance between wall plate & top of ridge.

⑪ Verge → It is the edge of sheet or tiles, projecting beyond gable end



Types of Roof

① Gable roof ② Gambrel roof ③ Flat roof ④ Shed roof



⑤ Hipped roof ⑥ mansard roof

→ Sloping in four directions but with break in slopes.

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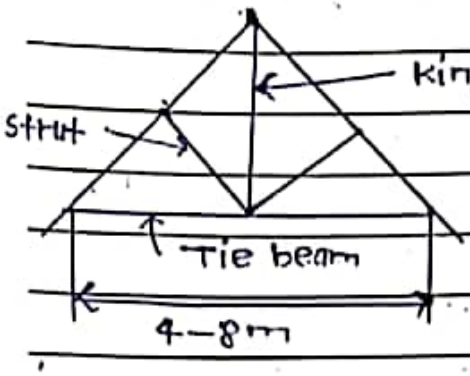
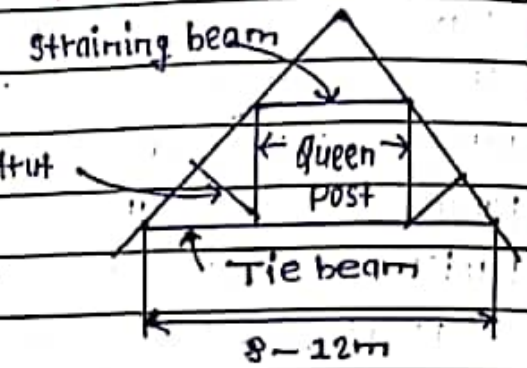
King post Truss



Queen post Truss



Wood Work

→ Timber is a very good ingredient for any types of constuction.

→ Used in form of frame, shutter, flobring, stair, form work.

→ Moisture content should not be more then 12%.

→ Wood for frame is measured in m^3 & shutter in m^2.

Technical Terms

① Bottom rail → Lower most horizontal member of shutter.

② Cross rail → Additional horizontal rail fixed betn top & bottom rail of shutter.

③ Top rail → Top most horizontal member of shutter.

④ Lock rail → middle most horizontal member of shutter.

⑤ Frame → Assembly of horizontal & vertical member in which shutters are fixed.

⑥ Shutter → openable parts of door & window.

⑦ Head → Upper most horizontal part of frame.

⑧ Sill → Lower most horizontal part of wall on which window frame rests.

⑨ Horn → Horizontal projections of the head & sill of frame to facilitate the fixing of the frame on the wall opening.

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(10) Hold fasts → made of mild steel flat bars.
→ provided on both sides of the vertical door/window frames to keep them in required position.
(11) Jamb → Vertical wall face of an opening which supports frame.
(12) Mullion → Vertical member of frame which is employed to divide a door or window vertically.
(13) panel → Area of shutter enclosed beth adjacent rails.
(14) post → Verticle member of door frame.
(15) Joist → Horizontal or vertical member to resist vertical or inclined forces.
(16) Reveal → External jamb of door & window opening ⊥ to wall face.
(17) Rebate → Depression made inside the door frame to receive the door shutter.
(18) Style → Verticle outside member of shutter of door or window.
(19) Transom → Horizontal member of frame, which is employed to sub-divide a window opening horizontally.

Note: → minimum & maximum thickness of shutter = 20 & 38mm
→ Normaly C/s area of post & head is kept same.
→ Thickness of door frame = 60 – 75 mm.
→ Wide of door frame = minimum 100mm. one side shutter.
= 125 – 140mm for both side shutter.

Door

→ Door is a framework of wood, steel, aluminum, glass or combination of these materials secured in an opening left in a wall for the purpose of providing access to the users of structure

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Functions of Door

→ It is provided to give access to the inside of room of house → provides lighting & ventilation to rooms.
→ It serves as a connecting link between the various internal portion of a house.
→ Controls the physical atmosphere within a space by enclosing it.
→ They act as a barrier to noise.

Types of Doors

① Battened & ledged doors → simplest type of door.
→ Used at place of narrow opening with less significance.
→ The vertical members are batten & horizontal members are ledge
→ It has single shutter.
② Battened, ledged & braced doors → Improved over the battened & ledged door with additional inclined member brace.
→ Used for wider opening.
③ Battened, ledged & framed doors → Improved over the battened & ledged door.
→ It contains frame in which shutter is fitted.
④ Battened, ledged, braced & framed doors → Improve over the battened, ledge & framed door.
→ Diagonal ledge are provided to increase its strength, durability & appearance.
⑤ Framed & paneled doors → Widely used for all type of building.
⑥ Glazed or sash doors → This door is provided where additional light is required. → Used for residential & public building.
⑦ Flush doors → popularly used in residential, public & commercial building.

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⑧ Louvered (Ventilation) doors → It provides ventilations as well as privacy in the room.
→ provided in lattrines & bath rooms of residential buildings.
→ Louvers are arranged at such an inclination that vision is obstructed while they permit free passage of air.
⑨ Wire gauged doors → These doors provided circulation of air while check the entry of mosquitoes, insects etc. it is common used in hotels, refreshment rooms etc.
⑩ Revolving doors → provided in public building where visitors are restricted to limited number. → It provides entrance & exit to one-one people simultaneously.
⑪ Sliding doors → Shutter slides on the sides with the help of runners & guide rails.
⑫ Swing doors → Shutter can move both inward & outward as desired.
⑬ Collapsable steel doors → Used in godowns, workshops, public building etc. → for providing increased safety & protection to proper
⑭ Rolling steel shutter doors. → Commonly used for garages, shops fronts show windows etc.

Window

Window is the opening provided in wall to admit light & air to th room & to give a view to outside.

Types of Windows

① Bay Windows → provided outside the external wall of room.
② Casement Windows → Common type of windows provided in buildings.
③ Clear-storey window → provided in a room which has greater

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ceiling height then surrounding room.

(4) Corner window → The window, which has two/more direction & are provided at the corner of building.

(5) Dormer window → It is vertical window provided on sloping roof.

(6) Double hung window → This window consists of frame & pairs of shutter, arranged one above other. which can slide vertically within grooves provided in window frame.

(7) Fixed window → shutter are fully glazed for admitting light & window frame has no rebates.

(8) Gable window → It is a vertical window provided in gable end of pitched roof.

(9) Louvered window → It provides ventilations as well as privacy in room.

(10) Lantern window → provided over flat roof to provide more light & air. → window project above roof level.

(11) Metal window → made of mild steel. → more popular in private & public buildings, because good strength & less cost.

(12) pivoted window → The shutter can swing or rotated either horizontally or vertically within the grooves provided in window fra

(13) Sliding window → shutter move either horizontally & vertically on small roller bearings.

(14) Glazed or sash window → Shutter are fully glazed.

(15) Sky light → provided on sloping roof, to admit light.

(16) Ventilators → small window fixed at greater height then window, about 30–50 cm below the roof level.

Note: → Breadth of window $= \frac{1}{8} \times$ [width of room + height of room]

→ Window opening = 10–20 % of floor area of room.

→ Window opening $\geq 1 m^2$ for every $30 m^2$ of room.

→ Glazed panel window > 8–10 % of floor area.

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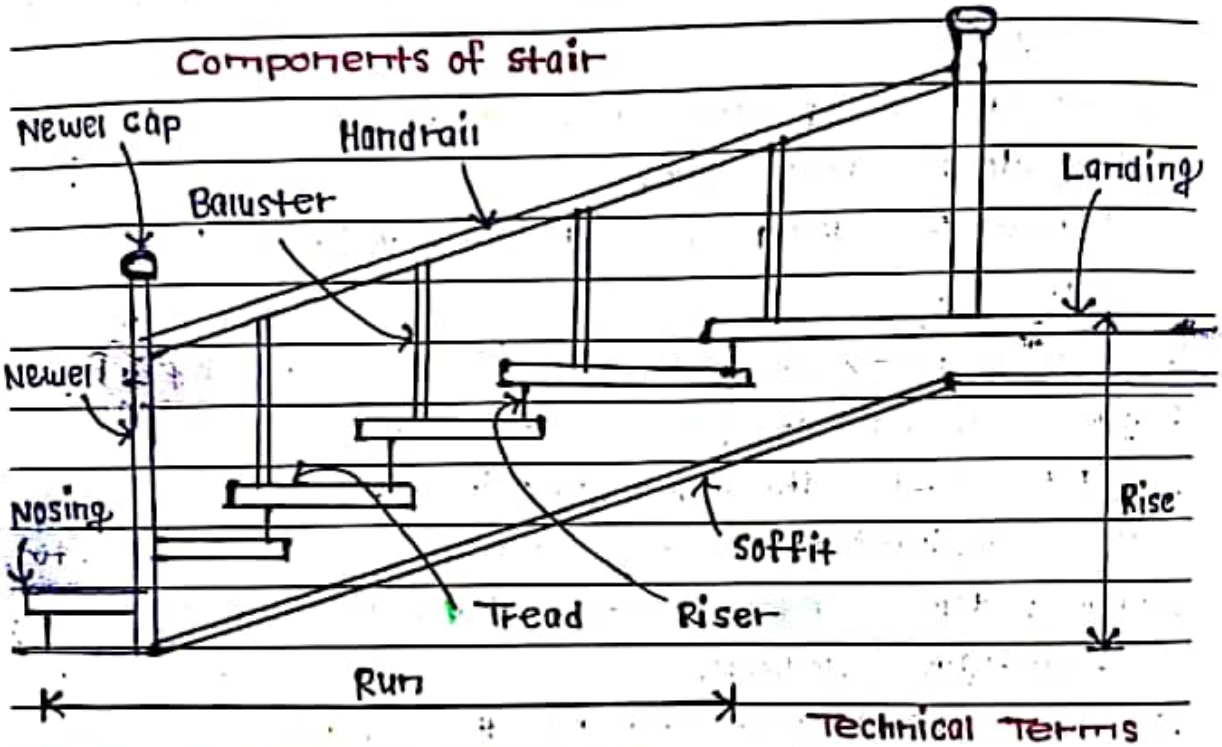
Stair

→ Stair is a series of steps properly arranged to connect differ floors of building.

Components of Stair



Technical Terms

① Riser → Vertical portion of step providing a support to tread.
→ Vertical distance between two consecutive tread is caned riser.

② Tread → Horizontal portion of step, which foot is placed while ascending & descending.
→ No. of tread in stair is always less then riser by one.

③ Flight → Unbroken series of steps betⁿ landings.

④ Landing → Level platform at top or bottom of flights betⁿ floors
→ It facilitates change of direction of flight.

⑤ Handrail → It is rounded or moulded member of wood or metal

⑥ Baluster → Vertical member of wood or metal.
→ Supporting the handrail.

⑦ Nosing → Outer projecting part of tread beyond the face of riser.

⑧ Newel post → Vertical member which is placed at the ends of

flights to connect the ends of strings & handrail.

(9) String → Also known as stringer or stringer board.
→ There are the structural supports that run along either sides of the staircase, through treads may be supported in many other ways.

(10) Stringers → sloping members which support the steps & run along slope of stair.

(11) Staircase → The room of building in which stair is located.

(12) Balustrade → Row of balusters surmounted by a handrail to protection for the users to the stair.

(13) Pitch → It is the angle which the line of nosing of stair makes with the horizontal. The pitch angle generally = 25°–40°.

(14) Run of stair → Total length of stair in horizontal plane including length of landing.

(15) Scotia → Moulding provided under the nosing to improve the elevation of step, & provide strength to nosing.

(16) Gooseneck → Vertical handrail that joins a sloped handrail to a higher handrail on the balcony or landing.

(17) Head room → Vertical distance betn 1st tread of a step & the bottom of flight or landing immediately above but should not be less then 2.13 m.

(18) Stair width → 1m for residential building
1.5m for commercial, public & hospital etc.

(19) Stairway → The opening or space occupied by stair.

(20) Waist → The thickness of RCC slab over which step of RCC rests

(21) Winders → They are angular or radiating steps & are provided to change the direction in the stairs.
→ Winders are the steps that are narrower on one side then other.

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→ A series of winders form a circular or spiral stairway.

→ Stairway winders or turns involve triangular treads to complete the turn.

(22) Step → portion of stair which permits ascent or descent.

→ It is comprised of tread & riser.

→ minimum & maximum step in flight = 3 & 15 respectively

Thumb Rule for Step Design

ⓐ R×T = 400 – 450 cm² ∴ R = Height of riser

ⓑ R+T = 40–45 cm T = Width of tread

ⓒ 2R+T = 60cm.

Requirements of Good stair.

① Location: provide easy access & get sufficient light & ventilation.

② Width of stair: It varies with the situation & purpose of stair.

→ Residential building = 90cm

→ Public building = 1.8m

③ Width of landing: At least equal to width of stair at any cases.

④ Length of flight: Unbroken series of steps called flight.

→ Max^m no. of steps in flight = 15 (NBC)

→ min^m " " " " " = 3

⑤ Pitch / slope of stair: 25° – 40°

⑥ Headroom: Clear vertical distance bet^n top tread & soffit of stair.

≥ 2.14m.

⑦ Step dimensions:

→ minimum width of tread = 25cm

→ maximum height of riser = 19.57cm.

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Types of stair according to method of construction,

① Straight stair → floor to floor, with or without landing.
→ Simple, economical, traditional.
→ Used where space is limited.

② Half turn → Two straight flight at 180° turn with mid land
* Dog-legged → mostly used in residential building.

③ Open well → Two or more then two straight flights arrang
around the well. → Mostly used in public building.

④ Spiral stair → Made from steel & Welded together.
→ Generally have winder steps.
→ Suitable where little space is available..

Requirements of Earthquake Resistant Building:

① Proper site selection → The construction site has to be stable & safe enough to withstand total building loads.

② Appropriate planning → The shape, size & proportion of buildings are important for its seismic safety.
→ symmetrical buildings are preferred.

③ Proportion → Length to breadth ratio of building should not exceed 3:1.

④ Good foundation resting on a firm base.

⑤ Better bonding bet^{n} masonry units.

⑥ Construction of sill & lintel bands

⑦ Building has to act like a single unit for better earthquake resistanc

permissible Settlement	Differential settlement
40 mm for isolated foundation on sand.	25 mm for foundation on sand.
40–65 mm for raft foundation on sand.	40 mm for foundation on clay.
65 mm for isolated foundation on clay.	
65 – 100 mm for raft foundation on clay.	