Lecture No. 1 **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Stone as building Material Criteria for Selection

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level
	Know the stone in detail for using it for building material.	Remember, Understand.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen.

Lecture Notes

Introduction:

* Building material is any material which is used for construction purpose.
* Natural substances – clay, sand, wood, rocks even twigs & leaves

Introduction to Stones:

* Stones – derived from rocks (earth's Crust)
* Stones – no definite shape (or) chemical composition but mixtures of two or more minerals.
* Minerals – formed by natural inorganic Process and possesses a definite chemical composition and molecular substance.

Important uses of stones: in civil engineering works:

* construction of residential and public buildings.
* construction of dams, harbours, abutment for bridges, etc.
* Face work of structures where massive appearance, solidity of construction and Ornamental features are the primary requirements
* Used as road metal and railway ballast.
* Used as aggregate for concrete.
* Used in the form of veneers for decorative front and interior of buildings.

classification of Rocks:

- Geological
- Physical
- chemical
- Practical

Geological classification:

- Igneous
- sedimentary
- Metamorphic

* Igneous - formed by cooling the molten lava on (or) inside the earth's surface during the volcanoic eruption.
  - lava comes out, cools down & forms non-crystalline nature called as Trap (or) Basalt.

- Portion remains inside undergoes cooling at a slow rate, results in formation of crystalline rock (Granite)

* Sedimentary Rock:
  - formed by gradual deposition of disintegrated rocks (rain, wind, temp. action), vegetable matter & clay @ bottom of rivers, lakes or sea.
  - also called stratified (formed in layers)
  - Ex: Limestone & stand stone.

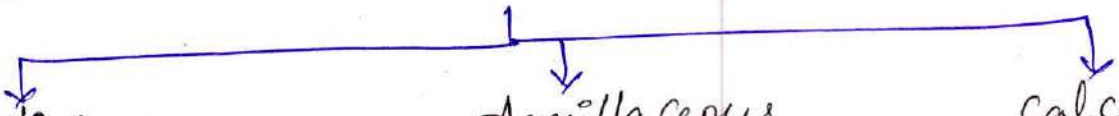
* Metamorphic Rock:
  - Sedimentary (or) igneous rocks, subjected to great heat & pressure inside the earth, a new variety of rock. (Metamorphic rock)
  - change in structure (metamorphism)
  - Eg: Lime stone → marble, slate → gneiss

2.) Physical:

Stratified
- distinct layers
- can be separated
- plane along which separation of layers carried out - cleavage plane.
- Ex: slate, limestone, sandstone

Unstratified
- do not show any sign of strata
- can't be split easily into slabs.
- Ex: granite, trap, marble, etc.

3.) chemical classification:



Siliceous
- silica (main constituent)
- silica in, free state (sand)
- combined state (silicate)
- Silica in, free state (harder)
- combined form get disintegrated
- Ex: sandstone, quartzite, etc.

Argillaceous
- Alumina
- Ex: slate, laterite, kaolin, etc

Calcarious
- Calcium carbonate (or) lime
- Rocks acts readily upon by even dil. HCl.
- Limestone, marble.

4.) Practical classification:
- based on usage.
- Granites, basalts, laterites, marbles, limestones, sandstones, slates.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 2. **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Criterial for Selection

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Understand the characteristics of stones	Understand

Teaching Learning Material	Student Activity
PPT	Listen.

Lecture Notes

Characteristics of Good Building stones:

Stones - application in - heavy structures - dams, docks, harbours, weirs, buildings etc.

To find the suitability of stone under different conditions, the foll. characteristics should be considered.

1.) Appearance and colour:

→ have uniform & appealing colour

→ free from flaws & clay holes.

→ stones with more iron not to be used because formation of iron oxide causes disintegration.

- stones should have the ability to receive good polish.

2.) Weight :

→ Specific gravity, weight of stone should be high

→ heavier stones resist the force of higher magnitude

→ heavy stone contains more compactness & less porosity.

3.) Porosity & absorption :

→ Porosity - greater pores stones not used for building construction, because during rain or water seeps → into pores contains acids & flames, which destroy stone.

→ During cold water entering pores freeze and split the stone.

4.) Fineness of grain :

* Fine grain → moulding works.
* Non-crystalline stone - disintegrate under action of natural agencies.

5.) Compactness :

* Compact stone - withstand the effects of external agencies effectively.

6.) Resistance to fire : Stone,

* should have homogeneous composition
* should be free from Calcium Carbonate (or) oxide of iron.

7.) Electrical resistance :

* To have steady & high electrical resistance, the stone must be non-absorbent like slate.

8.) Hardness & toughness: Stone must be hard & tough,
- to resist wear & tear.

* Hardness test - Scratching with pen Knife - no impression on hard stone like granite.
* Toughess test - hammer action on stone.

9.) Strength:

* Stones - subjected to compression, so that they should have enough strength to meet the requiremats
* Stones - high strength - heavy structures.

10.) Durability: A stone is more durable if it is,

* Compact * homogeneous &
* free from any material affected by dil. Hcl & Sulphuric acids, have negligible water absorption.

11.) Dressing:

* Art of shaping a stone - dressing.
* Stones - uniform texture & softness - easily dressed.
* Stones - too hard - finish will be poor & dressing uneconomical.

12.) Cost:

Cost of a stone depends upon,

* the ease with which it can be quarried out,
* Proximity of the quarry to the place of use.

* Availability of transportation facilities.

13.) Seasoning

* Good stone - free from quarry sap.
* Stones after quarrying & dressing should be left for a period of 6 to 12 months for proper seasoning before using in construction work.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 3 **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Testing of stones.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Know the testing methods available for stones.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk, PPt.	Listen.

Lecture Notes

Testing of Stones:

To determine the suitability of stone for its use in engineering works, the foll. tests are need to be done,

1.) Hardness test:

* Determined with the aid of Mohs scale of hardness.
* Pocket knife – mark on flesh surface of stone (say limestone) – Hardness, H = 3.
* Scarcely scratch with aid of a finger nail, H = 2.
* Can't scratch by a knife - Hard silicious rock, H = 7.

2.) Crushing Test:

* This test is done under compression.
* It is test in machine as follows;

→ Stones cut in cubes of size 40mm x 40mm x 40mm.
→ then finely dressed and finished.
→ Minimum three number of specimen are tested.
→ Specimens are placed in water for 72 hours prior to test.
→ Load bearing surface is covered with P.P. (or) 5 mm thick plywood.
→ Load is applied on cube with crushing test machine.
→ Rate of loading - 13.7 N/mm² per minute.

$$\text{Crushing strength} = \frac{\text{Maximum load}}{\text{Area of bearing face of the specimen}}$$

Hardness test:
→ Cylinder dia (25 mm) & height (25 mm) is taken and weighed
→ Dorry's testing machine - load 1250 g.m.
→ rotated - speed 28 r.p.m, coarse sand is sprinkled @ top of disc
→ After 1000 revolutions, the specimen is taken out & weighed.

$$\text{Co-efficient of hardness} = 20 - \frac{\text{loss in wt. (gm)}}{3}$$

3.) Impact test:
* Impact testing machine
* cylinder (dia - 25 mm, height - 25 mm).
* Cast-iron anvil of the machine.
* A steel hammer of 20 N → fall axially in vertical direction over specimen
* ht. of 1st blow - 1 cm; ht. of 2nd blow - 2 cm; third blow - 3 cm & so on.
* The blow at which the specimen breaks is noted.

4.) Fire resistance Test:

* Stone, free from calcium carbonate can resist fire.
* Few drops of dil. sulphuric acid on stone - produce bubbles.

5.) Attrition Test:

* To determine the rate of wear of stones
* Also known as abrasion test.
* Done in Deval's attrition testing machine.
  → 60 mm size (Broken out)
  → weight (50 N), dia of cylinders - 200mm; length of cylinders (340 mm)
  → Cylinders closed - axes angle 30° with horizontal
  → rotated about horizontal axis for 5 hrs @ 30 r.p.m.
  → sieved - 1.5 mm mesh.

$$\% \text{ wear} = \frac{\text{loss in weight}}{\text{Initial weight}} \times 100$$

6.) Acid Test:

* Stone - Kept one week in soln. of Sulphuric acid & Hcl having 1% strength.
* Corners of stones - high alkaline content turn roundish & loose particles get deposited on surface - unsuitable
* High % of lime - efflorescence - action of acids.

7.) Smith's Test:

* Presence of earthly matter
* Stone - broken into small pieces & put into a test tube with clear water.
* Test tube shaken vigorously, presence of dirty colour shows argillaceous matter.

8.) Electrical resistance / water absorption Test :

* Electrical resistance of wet stone is less & Porous stone have less strength.
* Stean sandstones should not absorb more than 10% of water, 17% - limestone, 1% - granites of water when dipped for 3-4 hrs.

Test Steps :

* Cube weight - 0.5 N - W_1 N.
* Immersed in distilled water for 24 hrs.
* Taken out & wiped with ~~water~~ cloth (W_2 N.

% absorption by wt. after 24 hrs $= \frac{W_2 - W_1}{W} \times 100$.

% absorption by vol. after 24 hrs $= \frac{W_2 - W_1}{W_2 - W_1} \times 100$.

% porosity by volume $= \left(\frac{W_2 - W_1}{W_2 - W_1}\right) \times 100$.

Saturation co-efficient $=$ $\frac{\text{water absorption}}{\text{Total porosity}}$

$= \frac{W_2 - W_1}{W_4 - W_1}$

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 4. **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Bricks, classification of Bricks.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Know the definition, & types of bricks.	Remember.

Teaching Learning Material	Student Activity
Chalk & Talk	Listen

Lecture Notes

Introduction - Bricks

Brick masonry - brick units bonded with mortar.

Strength of brick masonry, depends on, (i) quality of bricks.
(ii) quality of mortar
(iii) method of bonding used.

Advantages;

* All bricks - uniform in size, & shape, & hence they can be laid in any definite pattern.
* Brick units - light weight & small in size & hence can be easily handled by hand by brick layers.
* Bricks do not need any dressing
* Brick laying can be understood easily & even unskilled labours can do the brick masonry.

Types of Bricks.

Traditional

* NO standardized size
* length (20 - 25 cm).
  width (10 - 13 cm)
  thickness (5 - 7.5 cm).
* Approx. traditional brick size - 23 x 11.4 x 7.6 cm.

Modular.

* same uniform size (BIS).
* nominal size } - 20 x 10 x 10 cm
  actual size - 19 x 9 x 9 cm.
* Nominal size includes mortar thickness.

classes of bricks: (Based on quality)

First class bricks:

* standard size - 19 cm x 9 cm x 9 cm, laid in 10 layers will form masonry of 1 metre height.
* made from good quality plastic earth, which is free from saline deposits.
* good uniform colour, well burnt, hard ringing sound is emitted when two bricks are struct together.
* free from cracks, chips, flaws & nodules of lime. (1/6 th of their wt/.).
* when soaked for 1 hour, they do not absorb water, do not show any sign of efflorescence.

Second class Bricks:

* conform to standard size, slightly irregular in shape & colour.
* Soaked in water for 1 hr, they do not absorb water more than 1/4 th of their weight.

Third class Bricks :

* quite irregular in size, shape & finish
* Not burnt fully, due to which they are of reddish-yellow colour.
* Have low crushing strength.
* Not used for quality brick-masonry.

Definitions (or) Terms used :

* Stretcher - longer face of brick.
* Header - shorter face of brick
* Lap - horizontal dist. b/w vertical joints.
* Perpend - imaginary vertical line
* Bed - lower surface of the brick.
* Closer - cut made longitudinally. (Queen, King, Bevelled, Mitred closer).
* Bat - brick cut accross the width.
* Arris - edge of a brick.
* Bull nose - One edge (or) two edge rounded
* Quoin - corner (or) external angle on the face side of a wall.
* Frog (or) kick - indentation on the face of a brick to form a key for holding the mortar.
* Toothing - termination of the wall in such a fashion that each alternate course at the end projects when laid immediately below (or) above them.

Bond - interlacement of bricks, formed,

Types of bonds :

* Stretcher bond
* Header bond
* English bond
* Flemish bond
* Facing bond
* English Cross bond
* Brick on edge bond
* Dutch bond
* Raking bond
* Zigzag bond
* Gaarden wall bond.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 5 **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Manufacturing of clay bricks.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Understand the manufacturing process of brick.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk, PPT.	Listen.

Lecture Notes

Manufacturing of clay Bricks:

* Four different operations
  - → Preparation of clay
  - → Molding
  - → Drying
  - → Burning.

Preparation of clay

* Unsoiling of clay
* Digging
* cleaning
* Weathering
* Blending
* Tempering.

bricks

1. Unsoiling of clay.
   * The top layer of earth is removed (about 200mm)
2. Digging:
   * After removal, the required soil is dug out spread on levelled surface.
   * ht. of heap – 600–1200mm

3. Cleaning :

* After digging, the impurities like vegetable matter, stone, leaves are cleaned.

4. Weathering :

* For softening of soil, the soil is kept in open environment for some period of time. (few weeks to whole monsoons / seasons.

5. Blending :

* In this process, any other ingredient can be mixed in clay & the clay is made loose.

6. Kneading / Tempering :

* In this process, the water is added to clay and the whole mass is kneaded (or) pressed under the feet of men (or) cattle.

* For manufacturing good bricks on a large scale, the tempering is usually done in a pug mill. and the process is known as Pugging.

Moulding :→ moulding means to give desired shape to brick.

- Moulding
  - Hand moulding
    - Ground moulding
    - Table moulding
  - Machine Moulding
    - Plastic lay machine
    - Dry clay machine

Hand Moulding:

→ It is generally adopted when man power is cheap and production is small.

* As brick shrinks during drying & burning, so size of mould is kept 8 - 12% longer than the actual size of brick.
* Mould may be wooden or steel.

Ground moulding

* First - level the ground & sand or ash is sprinkled over it.
* Then place wet mold in the ground & fill it with clay & press hard to fill to the corners.
* Lift the mould & wet the mold by dipping it in water & repeat it.
* The process of dipping mould every time to make bricks is called slop molding.
* Frog mark of bricks - made - using pair of pallet boards (depth 10 - 20mm)

Table molded bricks:

* This process is similar to ground molding process, but here the bricks are molded on the table of size 2m x 1m.
* Ground molding is economical than table molding.

Machine Molding:

→ Molding achieved by machines.

→ It is economical when bricks are manufactured in large quantity

Plastic clay machine:

* Rect. open - equal to length & width of brick, plugged clay - machine & comes out through opening & cut into strips by wire

* Bricks are cut by wire => Wire cut bricks.

Dry clay bricks:

* Strong clay - powdered form

* Water is added - to form stiff plastic Plaste

* Then paste is placed in mold & pressed by machine

* Also known as pressed bricks & they do not require drying.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 6 **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Manufacturing of clay Bricks.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Understands & know the manufacturing process of bricks	Understand

Teaching Learning Material	Student Activity
Chalk & Talk, PPT	Listen

Lecture Notes

Drying :

* After ~~drying~~ molding, bricks contains moisture in it, so drying is ~~to~~ be done, otherwise they may cracked while burning.
* Drying of raw bricks – by natural process.
* Bricks - laid in stacks (8 to 10 stairs)
* Bricks - stacks - arranged in such a way. there should be circulation of air between the bricks.
* Period of drying – 3 to 10 days, depends upon weather conditions
* Drying ~~hard~~ yards – higher level.
* In some situations, artifical drying is is adopted under special dryers or hot gases.

Burning:

* In this process, brick attain "hardness of strength"
* Burning of brick should be proper, if brick is unburnt, then it will be soft and cannot carry loads
* If brick is overburnt, it would be brittle and distorted.

Process of burning

- Dehydration
- Oxidation period
- Vitrification

(i) Dehydration stage: [400°c - 650°c]
→ also called 'water smoking stage'
→ in this process water comes out, removed from clay pores after drying.

(ii) oxidation period/stage: [650° - 900°c]
→ Removal of carbon and sulphur is complete

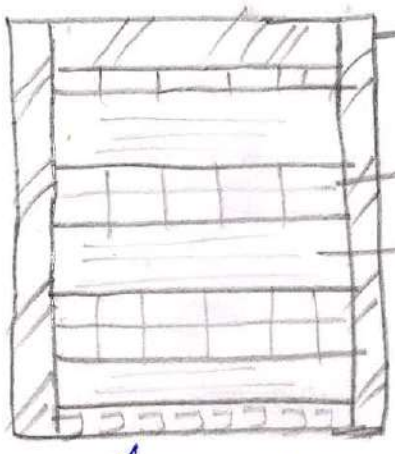
(iii) vitrification: [900°c - 1200°c]
→ Vitrification means to obtained a glass like substances
⇒ for soft clay [low melting clay], the temp [900°-1100°c]
⇒ for hard melting clay, [1100°c - 1200°c]

Burning of Bricks
- clamps
- klins

Clamps
[temporary structure for small scale manufacturing]

klins
[permanent structure for large scale manufacturing]

clamps : clamps :



→ [wood, rice husk ash, cow dung etc]
⇒ [1 - 2 months for burnt]

15°C ⇒ clamp is preferred in rural areas over kilns because it has initial cost.

⇒ ht. - 4 to 6 m.

Advantages : (i) Burning & cooling of brick are gradual in clamp. So durable strong brick can be obtained
* cheap, economical, * no skilled labour is required
* Not liable to rain & wind.

Disadvantages :
* Bricks are not of Regular shape.
* very slow process.
* Burning is not uniform, lower layer over burnt & upper layer - unburnt.
* Not possible to regulate fire in clamp burning.

kiln :

kiln

Intermittent Kiln.
[Loading, burning, cooling, unloading]
→ Up Draught kilns
→ Down draught kilns

Continuous kiln
[loading, burning, cooling, unloading can be obtained continuously]
→ Bull Trench kilns
→ Hoffman kiln
→ Tunnel Kiln

Up draught kiln.

* movement of the gases is allowed to take place in vertically upward direction.

* In down Draught kilns, permanent roof is provided along with the central chimney that permits the movement of the gases in ↓ direction.

* Quality of brick - better (DDK) than UPK.

Down draught kiln

* Movement of gases is allowed to take in vertically downward direction.

Continous kiln.

Bull trench kiln
↓
under ground structure
↓
don't have permanent roof
↓
movable chimneys
↓
most widely used in India.

Hoffman kiln
↓
over the ground structure.
↓
permanent roof
↓
fixed central chimney

Tunnel kiln
↓
form of tunnel
↓
Bricks are placed on trolley & is passed through dift. stationary zones in the tunnel.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 7 **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Tests for Bricks - Compressive strength - Water Absorption - Efflorescence.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	understand the various tests to be done on bricks	K2 Understand

Teaching Learning Material	Student Activity
Chalk & Talk.	Listen.

Lecture Notes

Tests for clay Bricks:

* Water absorption test
* Compressive strength test
* Efflorescence test
* structure test
* Shape and size test
* Soundness test
* Hardness test

Water absorption test:

* Specimen brick - first weighed dry.
* then immersed in water - 16 hours.
* It is weighed again; difference in weight indicates the amount of water absorbed by the brick.
* It should not in any case, exceed 20% of weight of dry brick.

Compressive strength test :

* Specimen brick - immersed in water for 24 hours.
* Frog of the brick - filled flush with 1 : 3 mortar.
* Brick is stored under damp jute bags for 24 hours followed by immersion in clean water for 3 days.
* specimen - plated b/w plates of compression testing machine.
* Load is applied axially at a uniform rate (of 14 N/mm²).

$$\text{Compressive strength} = \frac{\text{Maximum load at failure}}{\text{Loaded area of brick}}$$

* Crushing (or) compressive strength of common building bricks should not be less than 3.5 N/mm²
* Bricks of high quality do not have strength less than 14 N/mm²
* Roughly, the brick should not break when fallen on its end on their ground from a height of 1 metres.

Strength of the bricks is affected by;

→ composition of brick earth used.
→ Preparation of clay & blending of ingredients/constituents
→ Type of moulding adopted
→ Type of kiln used.
→ Burning & cooling process.
→ Care exercised in drying, stacking of raw/green bricks & in unloading of bricks.

Efflorescence test :

* Soluble salts → Present in the bricks cause efflorescence on the surface of bricks.
* To find out presence of soluble salt in a brick, it is immersed in water for 24 hrs.
* It is then taken out & allowed to dry in shade.
* Absence of grey (or) white deposists on its surface indicates absence of soluble salts.
* white deposists - 10% surface, efflorescence is said to be slight & it is considered as moderate.
* white deposists - 50% surface - moderate.
* white (or) grey deposists - more than 50% of surface - heavy & it is considered to be serious.

Structure Test :

* Specimen brick is broken & the structure is examined. It should be homogeneous, compact and free from any defects Eg : lumps, holes etc.

Shape & size test :

* Size & its shape should be truly rectangular with sharp edges.
* For good quality bricks, the results should be within the foll. permissible limits ;

Width - 3680 mm to 3920 mm
Height - 1740 mm to 1860 mm.

Soundness Test :

* It is performed by striking two specimen bricks with each other, the bricks should not break and a clear ringing sound should be produced.

Hardness Test :

* This test is conducted by making a scratch on brick with the help of a finger nail; if impression is left on the surface, the brick is treated to be sufficiently hard.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 8. **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Lime – Preparation of lime mortar.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Know about the lime and its preparation of mortar.	Understand

Teaching Learning Material	Student Activity
Chalk & Talk, PPT	Listen.

Lecture Notes

Lime:

Lime is Produced by heating limestones which is more or less Pure Calcium / carbonate.

Lime / quick lime / Calcium oxide.

Lime mortar – mixture of lime (fat lime (or) hydraulic lime), sand & water.

Fat lime – acts as binding material is added for Preparing mortar – used in masonry work.

Hydraulic lime – is added – used in foundation work (or) in damp conditions

Lime to sand ratio – 1 : 2.

Sources of lime:

→ L.S found in Limestone hills
→ L.S builders – beds of old rivers
→ Kankar – below ground
→ shells of sea animals
→ white chalk (pure L.S) & kankar (impure L.S)

Preparation of lime mortar :

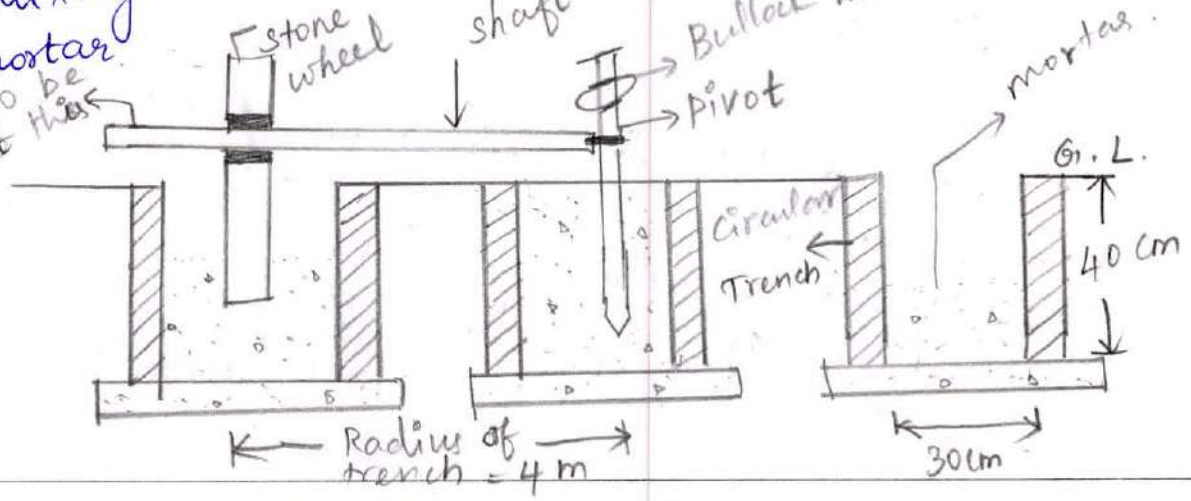
- Manual mixing
- Mill mixing
  - Bullock driven grinding mill
  - Power driven grinding mill

Manual mixing

* Small quantity
* lime + sand + other ingredients – water tight platform / small shallow tank.
* water is then added & mixing is continued till consistency is obtained.

Bullock driven grinding mill :

* small scale – circular mill.
* slaked lime & sand are mixed in specific proportions with / without water on dry platform.
* this mix → fed to mortar mill.
* Bullock continuously rotate the shaft for Crushing the mortar mix by means of stone wheel
* Crushed mortar – continually thrusted by means of 'spoons'
* Mortar – if needed is added during grinding so as to maintain the consistency of paste
* Mixing continued – till fine fine crushing of lime mortar.



By Power-driven mortar mill:

* It can produce mortar on large scale.
* This mill runs with the help of Electricity
* Power-driven mill consists of Rollers, Fixed steel pan, Pulley, Pivot, mortar, etc.
* This method is employed when a steady and a continuous supply of lime mortar is required.
* This method of grinding is more efficient and produces mortar of better quality

Properties of lime mortar:

* quite plastic & workable when wet
* good working qualities, if made from high calcium limes
* They develop strength very slowly, but gain Continuous strength over long periods.
* Not set - but stiffen - by evaporation.
* Provide enough bond b/w masonry blocks or bricks when used for masonry joints

Use of lime mortar:

* Masonry works with stones, bricks (or) Concrete blocks together.
* chimneys - continued strength development over a long period.
* Masonry & plastering in cheap & light load bearing wall.
* internal work with very thin mortar joints, or external walls in sheltered conditions, where the mortar is protected by a frost-resistant pointing

Dressing of stones:

* It is a process in which the stones surfaces especially the facing are prepared to a form fit to be used for any construction work.
* Dressing of stones;
  (i) gives the desired shape to stones,
  (ii) reduces the mortar joint width
  (iii) improves the appearance of stone surface.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 9 **UNIT I – STONES - BRICKS - CONCRETE BLOCKS - LIME**

Topic(s) to be covered	Concrete hollow Blocks - light weight concrete blocks.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Concrete Hollow Blocks:

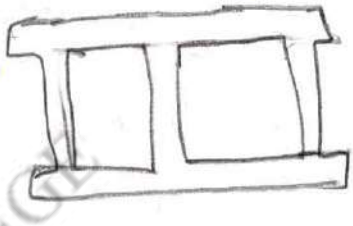
* The CHB - prepared from stone & gravel aggregates.
* But, now Crushed & graded cinders are extensively used for preparing these blocks, as these are highly cellular, light in weight, fire resistive, insulating & provide good mortar bond
* Light weight - concrete blocks - used for load bearing walls as well as partitions.
* These blocks for walls are 5 cm thick.
* Modular dimensions - 20x30x40; 20x20x40, 20x10x40.
* CHB - Void area greater than 25% of gross area, Solid area - should be more than 50%.

Types of Hollow concrete Blocks:

* Stretcher block
* Corner block
* Pillar block
* Jamb block
* Partition block
* Lintel block
* Frogged brick block
* Bull nose block

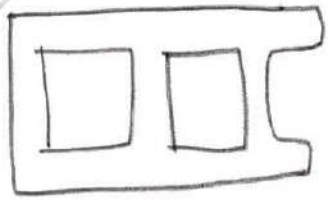
Corner stretcher block:

→ Used to join corner in the masonry.
→ widely used in construction
→ laid with their length ||el to the face of the wall.



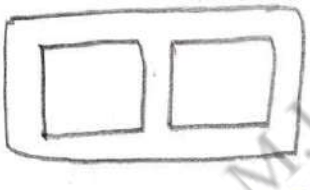
Concrete Corner blocks:

→ used @ the ends / corners of masonry
→ ends may be window or door openings etc.
→ Arranged - plane end visible to the outside and other end is locked with stretcher block



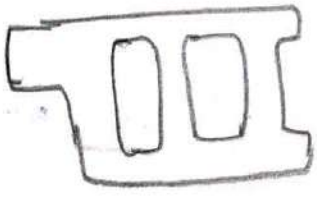
Concrete pillar blocks:

* Also called as double corner block
* used when two ends of the corner are visible
* In case of piers or pillars these blocks are widely used.

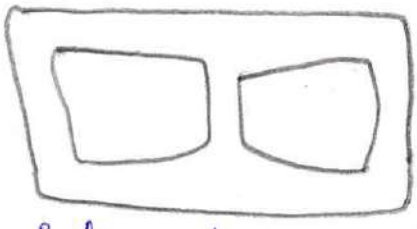


Jamb Concrete blocks:

* used when there is an elaborated window opening in the wall
* They are connected to stretcher & corner blocks
* For the provision of double hung windows, jamb blocks are very useful to provide space for the casing members of window.

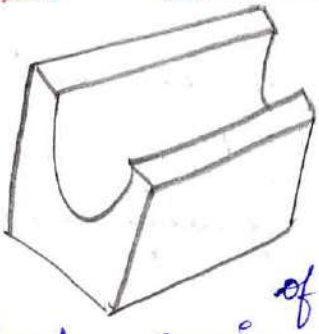


Partition concrete block :



* used to build Partition walls
* They have larger height than its breadth
* Hollow part is divided into two or three components in case of partition blocks.

Lintel Blocks :

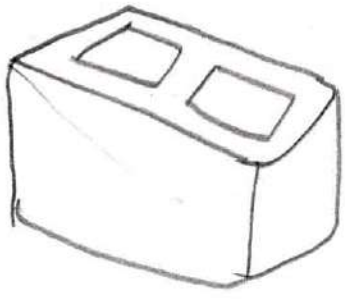


* Lintel (or) beam blocks - used for the purpose of provision of beam or lintel beam.
* Provided on the top portion of doors & windows, which bears the load coming from top.
* Concrete lintel blocks have deep groove along the length of block.
* After placing the blocks, this groove is filled with concrete along with reinforcement

Frogged brick blocks :

* This block contains frog on its top along with header & stretcher like frogged brick.
* This frog helps the block to hold mortar & to develop strong bond with top laying block.

Bullnose concrete block :



* these are similar to corner blocks.
* Both blocks are same but when we want rounded edges at corner bull nose bricks are preferred.

Light weight concrete blocks:

* Light wt. aggregates are used.
* Not strong – but used as good sound insulation & thermal insulation properties
* Foamed concrete blocks – special type of units under this category.
* Used – Various parts of masonry wall.
* Concrete Association of India,
→ face thickness – not less than 5 cm &
→ net area – at least 55 to 60 % of gross area.
* Course should be at least two in number & they should have preferably oval shapes.
* Commonly used sizes,

(a) 39 x 19 x 30 cm

(b) 39 x 19 x 20 cm

(c) 39 x 19 x 10 cm

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	Title	Author	Publisher
1.	Building construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 1 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Timber -

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	
	Knows the Timber properties, uses & understand the process to be done before using it for construction.	

Teaching Learning Material	Student Activity

Lecture Notes

Timber :

* Timber is the wood suitable for building (or) engineering purposes & it is applied to trees measuring not less than 0.6 m in girth.

Terms related to timber :

Standing timber - living tree
Green timber - freshly felled tree (no lost of moisture)
Rough timber - felling a free.
Converted timber - sawn, placed & worked to exact (beams, battens, planks etc)
Structural timber - framing & load bearing structures
Clear Timber - free from defects & blemishes (stains)

Properties of Good Timber

* should have - uniform colour
- regular annular rings, - straight & closed fibres, - heavy in weight, - fibrous tissues adhere firmly together, - fire-resistant, - hard
- free from shakes, flaws, dead knots or blemishes of any kind.

Advantages of Timber :

* easy to handle & can be planed, sawn & jointed with simple carpenters tool
* easily available & can be quickly transported by simple means
* light in weight yet strong.
* good insulator of sound & heat.
* when properly protected timber structures may give good service for hundred of years.
* It stand shocks & bumps.

Dis advantages of Timber :

* ready combustibility.
* can be destroyed by decay by fungi & by insects
* Timber swells & undergoes shrinkage with changing atmospheric humidity.

Uses of Timber :

* form of piles, posts, beams, lintels, door, window, roof members (rafters, purlins etc)
* flooring, ceiling, panelling &
* formwork for concrete - timbering of trenches, centering for arch work, scaffolding
* furniture, musical instruments, railway sleepers, agricultural implements.

Classification of Timber (PPT)

On Basis of ;

- Positions
- Gradings
- Modulus of Elasticity
- Availability
- Durability & Treatability

Defects in Timber :

- due to conversion
- due to fungi
- due to natural forces
- due to insects
- due to seasoning

Decay of Timber :

* Moisture, imperfect seasoning.
* Alternation of dry & wet stages.
* vegetable growth.
* Attack of insects.
* Bad storage / stacking of timber
* Unseasoned timber – protective coat of paint/tar/preservative on its surface.
* decay by fungi.
* Diseas of timber (Dry rot & wet rot)

Preservation of Timber :

Objectives :
- attack of destroying agencies (fungi, insects)
- lengthen the life of timber structures
- make timber structures durable.

Requirements of good preservative :

* cheap & easily procurable, free from obnoxious smell
* not be washed away by water.
* neither reduce streyth of timber nor Corrode metals.
* inflammable, good power of penetrating into fibre.

Methods of Preservation.

1. Tarring 2. charring 3. Painting 4. Creosotting
5. Ascue treatment 6. Fire proofing 7. Abel's process

Seasoning of Timber.

- The process of drying of timber.

Methods →
- Natural
  - Air drying
  - water seasoning
- Artificial
  - Kiln, - chemical
  - Electrical.

Types of Preservative Treatment.

- surface Application
- Soaking treatment
- Hot & cold process
- Boucherie process
- pressure process

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 2 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Market forms of Timber, plywood, veneer.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Market forms of Timber:

Batten : Breadth & thickness do not exceed 50mm

Baulk : roughly squared timber pieces & it is ~~removed~~ obtained by removing bark & sap wood, either c/s dimension exceed 50 mm & the other 200 mm

Boards : plank : (timber with 11el sides). thickness less than 50 mm & width < 150 mm.

Deal : pieces of soft wood with 11el side. thickness (50 to 100 mm) & width ≯ 230 mm.

End : short piece of batten, deal, scantling etc.

Log : Trunk of tree obtained after removal of branches.

plank : timber pieces with 11el sides. Thickness (50 to 100mm) width ≯ 230 mm.

pole : sound long log of wood. diameter ≯ 200mm. also known as spar.

Quartering : square piece of timber, length (50 to 150mm)

Scantling : Breadth & thickness ≯ 50 mm to ≮ 200mm in length. ~~(50 to 200~~

Veneers

* Thin sheets or slices of wood of quality.
* Thickness – 0.40 mm to 6mm or more.
* Obtained by - rotating a log of wood against a sharp knife (or) rotary cutter of saw.
* Veneers after being removed are dried in kilns to remove moisture.
* Edge of veneers are joined & sheets of decorative designs are prepared.
* Indian timbers – mahogany, oak, rosewood, sissoo, teak, etc.
* Veneering – process of preparing a sheet of veneers
* Veneers used to produce - plywoods, battenboards & laminboards.

Plywoods:

* ply means - thin layer.
* prepared from thin layers of wood or veneers.
* Two or more veneers in odd nos. are placed one above the other with the direction of grains of successive layers @ right angles to each other.
* Held in position by application of suitable adhesives.
* placing of veneers normal to each other. increase the longitudinal & transverse strength of plywoods.
* pressure applied – hot or cold.
* For hot pressure – hydraulic press is employed to press plywoods (temp. 150°c to 260°c)
* For cold pressure - 0.7 to 1.40 N/mm^2.
* used in ceilings, doors, furniture, partitions, railway coaches, form work of concrete

* Not suitable in situation subjected to schocks or inpacts.

* plywoods available in different commercial forms - batten board, laminboard, metal faced plywood, veneered plywood, etc.

Advantages of Plywoods:

* Ply placed @ right angles to each other, expansion & shrinkage are very low.

* Available in large sizes. (Commercial Sizes widths (150 cm) & lengths upto 300 cm.

* They are elastic & hence they are not liable to split or crack due to changes in atmosphere.

* Light in weight

* Not affected by moisture

* Stronger than solid boards

* very easy to work & they can be made to suit any design.

* Do not split in any direction

* Do not split when nailed near edges because quite economical way.

* Make use of rare & valuable timbers in a quite economical way.

* possess uniform tensile strength in all directions.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 3. **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	False ceiling Materials.

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

False ceiling Materials:

* A false ceiling is a fitted ceiling that is suspended below the original ceiling of a room or home.
* Usually provided for temperature control like heat insulation for air conditioning, to install lights or to conceal electrical & other networking cables.

Types of false ceiling.

1.) Gypsum false ceiling:

* hydrated sulfate of calcium.
* Light wt., sound insulated, fire resistance, soft & thermally insulated
* They comes in shape of square boards that are hung with the help of iron framework.
* The finishing works on these boards like Paints, laminates, Wallpapers & texture finish gives good appearance.

2.) plaster of Paris ceiling : (POP)

* Majorly used material in the construction of false ceiling.
* Gypsum is heated to certain degree – POP.
* Both aesthetical & functional purpose.
* POP - more attractive, no maintenance req. & has a long life span.
* very excellent insulators of heat & cold.

Fibre false ceiling :

* High demand for const. of false ceiling due to low cost & easy installation
* Materials used - man made by Synthetic & natural minerals.
* Since man-made, they come in many shapes & sizes.

Wood false ceiling :

* commonly used - due to its natural textures, pattern & pleasant look.
* costly - not used in malls & hospitals but can be installed in residential buildings.
* can be given various finishes & paintings to get the right look.
* Main disadvantages - termite attack & warping.

Glass false ceiling :

Glass
* Non-Crystalline – brittle & transparent, but this can be altered to make non brittle & non-transparent using admixtures.
* As glass is a good insulator of heat, it can be used for false ceiling.
* This type improves aesthetical appearance of the building.

Metal Ceiling:

* Metal - hard & durable material, hence used in false ceiling.
* Metals used - galvanized iron & aluminium.
* Cost is low & easy to install & access.
* Hidden members of the structure are easily removable & reattached.
* Installation, fixing & maintainance cost is low.

Synthetic leather / cloth ceiling:

* Material used - leather / cloth.
* Both man-made & hence they can be given any form, shape & design.
* As these collects dust & has low light transferring property its used in temporary tents or any other temporary buildings.

Advantages:

* Easy to install & cheap as compared to traditional roof systems.
* It provides a smooth homogeneous surface to roof & helps in acoustics.
* ~~provides~~ smooth ho conceals all the non-pleasing elements & hides it from the viewers eyes.
* It provides fire protection.

Disadvantages:

* false ceiling would pests, they can get through into space b/w & can start their own breeding which might leads to a lot of trouble.

* False ceiling would reduce the height of the ceiling.

* Decorations or hangings in false ceiling can be done only after considering the strength & durability of the false ceiling.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 4 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Steel - Mechanical treatment

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Steel :

Steel is an alloy of iron & Carbon containing less than 2% Carbon and 1% Manganese & small amounts of silicon, phosphorus, Sulphur & oxygen.

Steel is the most suitable building material & is classified on the basis of Carbon content.

Types of steel	Carbon content
Mild steel	0.15 - 0.3
Dead mild steel	< 0.15
Medium carbon steel	0.3 - 0.8
High carbon steel	0.8 - 1.5

(>1 is also called as Cast steel or tool steel)

Types of steel:

Mild steel:

* low carbon (or) soft steel.
* Ductile malleable, tougher & more elastic than wrought iron.
* It rusts quickly & can be permanently magnetised.
* .S.G - 7.30, ultimate compressive (800 to 1200 N/mm^2) and tensile strength (600 - 800 N/mm^2)
* Used in rolled sections, reinforcing bars, roof coverings & sheet piles & in railway tracks.

Wrought iron:

* less than 0.15 % carbon
* made from white pig iron by removing carbon, manganese, silicon, phosphorous & sulphur by puddling process.
* Uses - Spikes, nails, bolts & nuts, chains, Straps for timber roofs, pipes etc.

Cast iron:

* 3 to 5 times stronger in compression than in tension.
* Strength in compression (560 N/mm^2)
* Strength in tension (140 N/mm^2)
* Melting temp. (1200 °c), Cast iron is cheap & used in manufacture with simple tool in small factories, very resistant to corrosion & used in rainwater pipes, flush-water.

High Carbon steel:

* high carbon steel (0.55 to 1.50 %)
* tougher & more elastic than mild steel.
* ultimate compressive strength - 1350 N/mm^2 & ultimate tensile strength (1400 - 2000 N/mm^2)

* S.G - 7.90

* Uses - reinforcing cement concrete & pre-stressed concrete members. It can take shocks & vibrations, tools & machine parts.

Manufacturing Methods:

Bessemer process; Cementation Process, Crucibe process, Open Hearth process, Electric Smelting process, Duplex process, Lintz & Donawitz (L.D) process.

Properties of steel:

Hardness: → ability to withstand friction & abrasion

Toughness: ability to absorb energy without fracturing (or) rupturing

Yield strength: measurement of the force required to start the deformation of the material

Tensile strength: measurement of the force required to break the material.

Elongation: 'degree' to which the material can be stretched or compressed before it breaks.

Corrosion: destruction of steel material due to chemical reaction of its surface to environment factors such as acids, moisture & oxygen.

plasticity: deformation of a material undergoing non-reversible changes of shape in response to applied forces.

Malleability: which they can be hammered, shaped & rolled into a very thin sheet without rupturing

Defects in steel : * Cavities / blow holes
* cold shortness * Red shortness * Segregation.

Cavities / blow - holes :

* formed when gas is confined or imprisoned in the molten mass of metal, producing bubbles (or) blow - hole on solidification of metal.

cold shortness :

* This defect is due to the presence of excess amount of phosphorus, Cracks in cold state

Red shortness :

* this defect is due to the presence of excess amount of sulphur, cracks in hot state.

Segregation :

* Some constituent of steel solidify at an early stage & they separate out from the main mass.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 5 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Mechanical treatment of steel, Aluminium.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Mechanical treatment of steel:

⇒ Purpose - give desired shape to the ingots so as to make steel available in market forms.

* Treatment for steel – hot / cold working.
* Hot working is very common.

Drawing:

* This is done to reduce the c/s & to increase the length.
* Metal drawn thro' dies / specially shaped tools
* This continues until wire of required dia / c/s is obtained.
* Uses – Prepare wires & rods.

Forging:

* This is done by repeated blows under a power hammer or a press.
* steel may be either forged free (or) die forged.

* The riveting belongs to forging operations
* Uses - manufacture of bolts, clamps etc.

Pressing:

* slow process & it is carried out in an equipment known as the press.
* does not involve shock.
* Press consists of die and a punch.
* Uses - when a large number of similar engineering articles are to be produced.

Rolling:

* This operation is carried out in specially prepared rolling mills.
* Angles, channels, flats, joists, rails etc are obtained by the process of rolling.
* It is possible to prepare jointless pipe with the help of this process.

Uses of steel: * properties of Mild & Hard steel

* steel is environment-friendly, durability.
* recyled material
* It gives better shape & edge than iron which is used to make weapons.
* Automobile industry - car body, doors, engine, suspension
* Mild steel - building construction.
* make large sheets
* offshore platforms & pipelines.

Aluminium :

* Silvery - white metal, widely used in building because of its inherent properties of lightness & corrosion resistance.
* Principle constituents of bauxite ($Al_2O_3 2H_2O$) which yield Aluminium on a commercial scale are hydrated oxides of aluminium & iron.
* Ore is purified by Bayer's process & is reduced to Aluminium by Hall Hiroult's process in two stages.

Properties of Aluminium :

* Aluminium - silver white in colour with a brittle metallic lusture on freshly broken surface.
* It is mallable, less ductile than copper but excess zinc, tin & lead.
* Very light, soft, strong and durable
* low thermal conductivity but good conductor of electricity.
* Aluminium can be riveted & welded, but cannot be soldered.
* Melting point - 657°c, tensile strength - 117.2 N/mm² (cast form) & tensile strength 241.3 N/mm² (drawn into wires)
* Aluminium - resistant to the stack of nitric acid, dissolves slowly in conc. sulphuric acid and is soluble in hydrochloric acid.

Uses of Aluminium:

* Pure aluminium (very soft) - unsuitable for structural purposes.
* Satisfactory properties derived by alloying copper, manganese, zinc, silicon, nickel with aluminium.
* Doors, window frames, railing of shops & corrugated sheets for roofing system.
* Aluminium powder – making paint.
* Making parts of internal combustion engine, airplanes, utensils, * packings for medicine, chocolates, etc.
* Aluminium alloy – manufacture of rolled sections, such as angles, channel, I - sections, round & rectangular pipes, rivets & bolts.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 6 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Alloys of Aluminium & Market forms of Aluminium.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Alloys of Aluminium :

* Aluminium – alloyed with copper or zinc to improve its mechanical properties.

Duralumin :

* 3 – 5 % copper, 0.5 – 1 % magnesium & 0 – 0.07 % manganese, 0.3 – 0.6 % iron, 0.3 – 0.6 % Silica. present as impurities.
* Relative density – 2.80
* Yield point – 206.85 N/mm^2.
* highly resistant to corrosion.
* wire & sheets – drawn from duralumin. (Construction – diff. shapes)

Magnalium :

* Alloy of aluminium & magnesium (6 %.)
* good mechanical properties & is little lighter than pure aluminium.
* Strong, mild ductile, easy to work & widely used as deoxidizers in copper smelting operations

Aluminium copper alloy:

* Contains zinc upto 15 %.
* less liable to burning the alloy produces light castings that are stronger & tougher than that made from aluminium.
* Used in automobile industry for casting.
* Aluminium zinc alloy — zinc upto 15 %.
* Light casting — machined or forged into desired form.
* very sensitive to high temperatures in melting
* Alloys containing 15 to 25 %. zinc — harder, stronger, but less ductile & more difficult to roll or draw.
* If % of zinc is increased above 25 %. the alloy suffers decrease in strength when excessively worked, either hot or cold.

Market Forms of Aluminium:

Casting based, Extrusion based, Foil and Powder based, sheets based.

Casting based:

Baluster head: — Cast aluminium baluster-heads add elegance to the interior of buildings & complicated figures can be developed.

Hardware & Fittings: - can be produced in casting process.

Security and decorative grills: - This application has tremendous potential in our country.

Extrusion based:

1) Doors & window frames:
* This is the major application of aluminium in buildings
* windows, side hung & fixed, side hung openable, sliding, top hung, etc.

2) Fascia panels & Curtain walls
* Larger Fascia panels & Curtain walls can be produced by using interlocking aluminium extrusion.

3) Geodesic domes & space grids:
* A Geodesic domes is a vaulted structure of light weight straight elements that forms interlocking Polygons.

4.) Green houses & roof top gardens
* For cold climates, the aluminium extrusions are used to provide green houses & roof top gardens.

5.) Hardware and fittings
* Hardware - handles, tower bolts, aldrops, Curtain rails, etc.

6.) North light glazing frames :- for industrial sheds.
- easy, quick way erection & maintenance free installation

7.) Partitions & space dividers - Office interiors.

Foil and Power based:

1.) Decorative laminate :- wall papers, partition panels, etc.

2.) Insulative foils :- air conditioning ducts in large central air - conditioned systems

3.) Paints :- Aluminium powder based paints - protection to the buildings against Corrosive environment.

4.) Water proofing sheet :- foil based laminates.

Sheet Based:

Cable tray :- Galvanized iron trays - Carrying insulated electric cables in industrial complex especially in chemical industries.

2.) Planar / flat type false ceilings: - exhibit supreme appearance.

3.) Prefabricated houses:
- It can be sandwitched with polyurethane to form a better material for this type of appln.

4.) Rain water articles:
- non-corrosive aluminium - gutter, spouts, etc. for disposal of rain water.

5.) Riding & angles of roof:
- flashing, monitor roofs & gable-end flashings.

6.) Roofing & siding:
- industrial buildings, workshops & sheets.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 7 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Glass – Ceramics – Refractories.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Glass:

* Glass – mixture of raw materials like silica, Sodium potassium carbonate, lime / lead oxide, manganese oxide which are grounded, sieved & mixed in specific proportion to make glass.
* Glass – hard, brittle, transparent (or) transulent material.

Properties of Glass:

U-Value * Amount of heat transferred through a glass.
* Insulated glass units provide low U value.

Transparency: Both side transparent / One side transparent & other sid mirror.

Work ability & Recycle property:
* Glass can be moulded into diff ~~Glass~~ shapes (or) blown during melting.
* 100 % recyclable & used as raw material in construction.

Strength : * brittle - but can make it stronger by adding admixtures & laminates.

Transmittance : - visible fraction of light passing through the glass.

* It is an excellent electrical insulator at elevated temperatures

* when it is heated, it becomes soft with rise in temperature. It is ultimately transformed into mobile liquid.

Manufacture of Glass : (4 steps)

* Melting * Forming & Shaping - Blowing - Flat drawing * Compression Moulding * Spinning * Annealing * Finishing.

Treatment of Glass :

* Bending * Cutting * Opaque making.

* Silvering.

Types of Glass :

* Soda - lime Glass | * Potash - lead glass
* Potash - lime glass | * Common glass.

Commercial forms of Glass :

Sheet Glass : * Glazing doors, windows & partitions.

plate glass : Sizes (2750 x 900 mm)

* Showcases, cabinets, making mirrors, shop fronts

Tempered glass : * Sports arenas, sliding-doors, curtain walls.

Wired glass : * fire resisting doors & windows, sky lights & roofs.

Obscured glass : * frosted, rolled & ribbed.

Laminated glass : heat proof glass, sound roof glass, bullet proof glass.

Heat & sound proof glass : - high resistance to heat & glare.

Bullet proof glass : - banks, jewellery stores & display.

Insulating glass : windows.

* 2 glass plates thick dehydrated air is sealed.

Heat absorbing glass :

* railway carriages, factories, hospitals, health clubs & kitchens.

Ground glass : - bedrooms, toilets, making black boards.

Coloured glass : - adding oxides of metals to molten glass.

Uses of glass :

* FGR + plastics - construction of furniture, cars, trucks, lampshades, bathroom fittings etc.
* Rifle barrel.
* optical glass - sciences of astronomy & bacteriology
* Hollow glass blocks - walls & ceilings of modern homes.

CERAMICS :

* Poly crystalline materials & products formed by baking natural clays & mineral admixtures @ high temp.
* Carbon, boron, silicon, carbides, silicates, refactory hydrides & sulphides - ceramics
* Conventional applications - lining, insulators, Crookeries.

classification :

* Refractories, Silicates, Glasses, Limes, Cements, Plain concretes, Prestressed concretes, Rocks & stones, Reinforced cement concrete; Abrasives, clay & clay products - bricks & tiles.

Refractories :

* Ceramic materials of specific nature which are capable of withstanding high temperature.
* Resist mechanical abrasion, infusion of molten metals, slag / metallic vapours.
* Eg: fireclay & high alumina brick.
* It must be capable of resisting compressive, crushing & tensile forces in hot/cold conditions.
* It should be able to withstand abrasion.

classification

according to chemical properties
- acidic
- neutral
- basic

according to resistance to temperature.
- high quality
- low quality

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 8 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Composite Materials - Types & applications FRP

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Composite Materials

* Material system - Composed of two / more dissimilar constituents differ in forms, insoluble in each other physically distinct & chemically inhomogeneous.

Types.

- Agglomerated composite materials
- Laminated Composite Materials
- Reinforced composite Materials

Agglomerated Composite Materials:

* Macroscopic particles - sand, gravel, abrasives, metallic & ceramic powders.
* Agglomerated particles & a matrix material monolithic construction - agglomerated structure.
* Eg: Cement concrete, Asphalt - Stone & asphalt brick, Abrasive grinding wheels (shops), Moulding sands (foundry shop), Cermets, Alloys.

Cermets : - Rotary drills in mining industries.
- cutting tools, shaping tools,
- cemented carbide, components in satellites & space-going vehicles.

Laminates :
* Layered composites made-up of many laminae.
* Lamina - ply or layer is very thin (0.1mm to 4mm thick)

Eg : plywood, sheet moulding compounds, Bulk moulding compounds, Linoleum, Tufnol

Plywood : - 5 to 7 plies are glued together so that the shrinkage stresses are symmetric about mid-ply & tendency of warping is minimum.

Metal to metal laminates - cladded metals.
- Pressure vessels, heat exchangers of process industries

Sheet moulding compounds - blend of resin, hardener, fibres, accelerator.

Reinforced Composite Materials :
(1.) Matrix / body constituent (2.) Reinforcing constituent

Commonly used reinforcing agents ;
(i) metals - steel in cement concrete
(ii) organic fibres - carbon, graphite, kevlar
(iii) inorganic fibres - glass, ceramics.

Applications :
* Space vehicles & satellites * Automobiles
* Aircrafts * Rockets * sports, music
* Building construction * Machine components
* Electronic & computer components

Fibre Glass Reinforced plastic : (FRP)

* FRP - formed by using two materials in conjunction with each other to form comp. mat
* Glass fibre reinforced plastic (or) GRP.
* Provides stiffness & strength while resin provides a matrix is transfer load to the fibres.
* Five principal methods.
  1. Filament winding,
  2. Hand lay-up,
  3. Pultrusion
  4. Resin transfer moulding
  5. Spray-up.
* Industries — chemical process industry
  - Fertilizer industry
  - Food processing industry
  - Oil & gas producing industry
  - paper industry, petrochemical.
  - pharmaceutical, - Thermal power generation.

Properties of FRP:

* Aesthetic appeal.
* Corrosion resistance
* Dimensional stability
* Durability
* Easy to repair
* Effect on health
* Energy saving
* Freedom of design
* Light transmission
* Light weight
* Low investments in tooling
* Maintenance.

Applications in Building industry :

* Concrete shuttering
* Domes
* Doors & window frames
* Internal partitions & wall panelling
* Roof sheets
* Structural sections
* Temporary shelters
* Water storage tanks
* Miscellaneous.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 9 **UNIT II – OTHER MATERIALS**

Topic(s) to be covered	Fibre textiles - Geomembranes & Geotextiles for earth reinforcement

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Fibre textiles:

* Textile fibre - spun into yarn (or) made into a fabric by various methods (weaving, knitting, braiding, felting & twisting.
* Other properties - elasticity, fineness, uniformity, durability & luster.

Types — Natural fibre
Man-made fibre

Natural fibre:

* Plants, animals & geological processes, biodegradable.
* A class name for various genera of fibers (including filaments) of;
  - Animal (ie., silk fiber & wool fiber)
  - Mineral (ie., asbestos fiber)
  - vegetable origin (ie, cotton, flax, jute, ramie fiber)

Man - made fiber :

* also known as Manufactured fiber.
* Synthetic / man - made fiber - Synthetic materials such as petrochemicals ; natural cellulose - rayon, modal & lyocell.

A class name for various genera of fibers ;

- Polymers - chemical compounds Eg : acrylic fiber, nylon fiber, polyethylene fiber, polyvinyl fiber
- Modified / transformed natural polymers

Eg : alginic & cellulose - based fibers - acetates fiber & rayons fiber.

- Minerals - chemically produced fibers

Eg : cotton, wool, silk, flax, ~~fibers~~ ~~fs~~

Eg : Glass fiber.

Geomembranes and Geotextiles for earth reinforcement :

Geomembranes :

* Impermeable membranes - cut-offs & liners.
* Uses - canal & pond liners, containment of hazardous (or) municipal wastes & their leachates.
* Geofabrics - also called as geosynthesis (or) geotextiles.
* Applications - geotextile or mesh underliners to reinforce or to protect the more flexible geomembrane, acts as an escape route for gases & leachates generated in certain wastes.
* Synthetic fibers - durable to last a good length of time in soil environment used in geotechnical engineering.

Uses :

* Drainage paths for water for soil consolidation
* Separation of diff. types of soil materials
* Soil reinforcement in reinforced earth construction
* Filtration of water from soil.

Geotextiles for Earth Reinforcement :

Geotextiles :

* permeable fabrics – soil – ability to separate, filter, reinforce, protect (or) drain.
* Intro – of geotextile composites & development of products such as geogrids & meshes.
* Use in soil – don't get deteriorate by corrosion in presence of chemicals.
* Used in Mechanically Stabilized Earth (MSE) (or) Reinforced Earth construction.

classification

- Geotextile
- Geogrids
- Geomembranes
- Linear strips for soil reinforcement.

Uses :

* As an embankments for flyover in cities occupy little width & by the use of geotextiles as soil reinforcement for these embankments – very handy.
* Much steeper slopes than normally only can be admissible with earth provided by using soil reinf. in the embankment.

* As soil reinf. for retaining walls & stability of slopes
* For improving bearing capacity of foundations
* As filtration medium for drainage
* New railway embankments for Indian Railways - using plastic geotextile drains.
* used under railway track to separate ballast from sub grade.
* used as drainage wicks to assist drainage & Consolidation of clayey deposits.
* They are efficient for soil drainage to assist in preloading of foundations.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. | UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Types of Foundations, Shallow & Deep Foundations.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

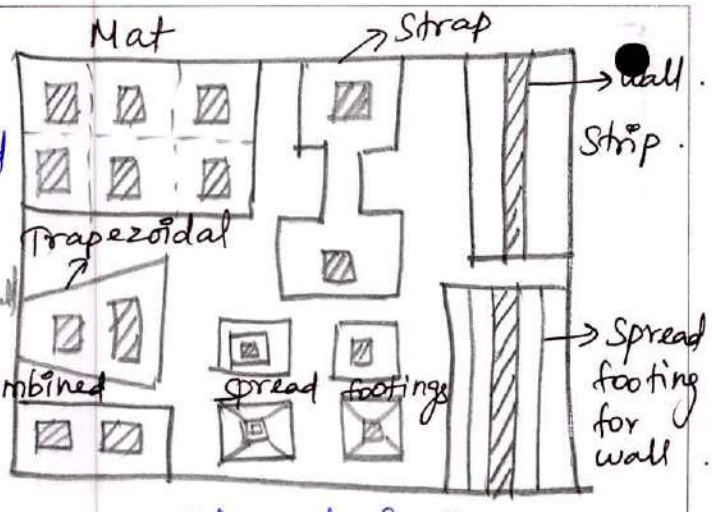
Foundation : * A foundation is therefore a part of the structure which is in direct contact with the ground to which the loads are transmitted.

* Lower most portion of foundation which is in direct contact with the sub-soil ⇒ footing.

Types of Foundations :

- Shallow foundations (up to 2m, depth ≤ width)
  - * Spread footing
  - * Combined footing
  - * Strap footing
  - * Mat foundation
- Deep foundations (depth ≥ width, more than 2m)
  - pile
    - Based on friction
      - * Bearing pile
      - * Friction pile
    - Based on material
      - * concrete
      - * Timber
      - * Steel
      - * composite
  - Pier
  - well

Shallow Foundations:



* Spread footings:

* Spread the super-imposed load of wall or column over a larger area. → Spread through single spread
  * single, ~~sto~~ footing - column
  * stepped - heavily loaded column
  * sloped — concrete base does not have uniform thickness
  * wall footing without step
    ↳ without any steps
  * Stepped footing - wall
  * Grillage foundation
    ↳ Steel stanchion carrying heavy load.

* Combined footings:

* Spread footing which supports two / more columns.

→ Rectangular (equal loads) → Trapezoidal (unequal loads) → combined column - wall.

* Strap footings:

* If the independent footings of two columns are connected by beam → strap footings
* strap footing is used where the dist. b/w columns is so great that a combined trapezoidal footing becomes quite narrow, with high Bendingmoment

* Mat (or) Raft foundation:

* Combined footing - covers entire area below the structure & support all the walls & columns.
* ~~a~~llowable soil pressure is low, building loads are heavy, use of spread footing cover more than one-half the area.
* Reduce settlement above highly Compressible soils.

Deep Foundations: depth of foundation > width of footing.

* **Pile foundation**.
  * load transmitted by vertical member – pile. (Steel, concrete & wood)

According to foundation:

End Bearing piles: → transfer load thro' water / soft soil to suitable bearing stratum..

Friction Pile:
→ where soil is soft @ considerable depth
→ transfer load to soil by friction b/w Soil & the pile.

According to Material:

* Concrete pile * Timber pile * steel pile * Composite pile.
* Pier Foundation (drilled caisson Foundation)
  * Vertical column of relatively larger Cross-section than pile.
  * dia ≥ 0.6m * shape – cylindrical.
  * Cast on site, used for heavy multi-storey structure, bridges, flyovers.
  * hard strata – 5m or less than 5 metre.

Masonry/concrete pier — * — Drilled Caissons

* **Well foundations (or Caissons)**
  * box like structure – circular (or) rect. which are sunk from the surface of either land (or) water to the desired depth.
  * bearing very heavy loads of the structure.

* Construction - help of auger & bear the heavy load of the structure
* Not used - loose & soft clay soils.

Factors for selection of suitable foundation type of for a Building.

* Building height
* Load condition
* Soil type
* Type of building.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 2 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Stone Masonry, Brick Masonry, plastering & pointing.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Stone Masonry:

* Used – walls, columns, lintels, arches, beams etc.,
* Adv: thermal & acoustic insulation, fire & weather protection.

Types

Rubble Masonry [Undressed (or) roughly dressed]

* Coursed Rubble
* Uncoursed Rubble
* Dry Rubble
* Polygonal
* Flint

Ashlar Masonry. [uniform & fine joints]

* Ashlar fine
* Ashlar Rough Tooled
* Rock (or) Quarry faced
* Ashlar block in course
* Ashlar chamfered.

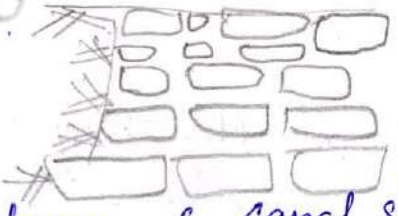
Coursed Rubble Masonry:

* equal heights
* possess diff. sizes.
* courses don't have same height.
* Public buildings, abutments, residential buildings.

Uncoursed Rubble Masonry: — Random uncoursed etc. \ Square uncoursed.

* cheapest & roughest
* varied shape & size.
* Undressed stone blocks.
* Spaces - filled with spalls / Sheeks.

Dry Rubble masonry:

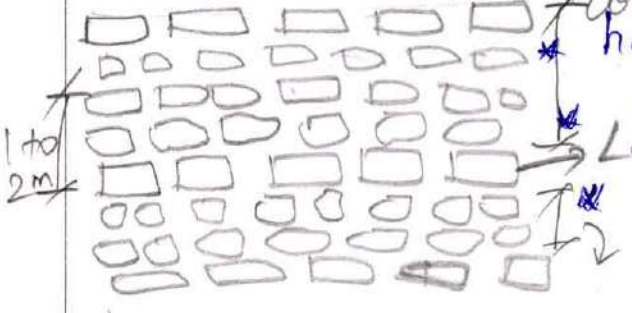


* without use of mortar.
* Small spaces filled with small stone pieces.
* Used - pitching the earthen dams & canal slopes.

Polygonal Rubble Masonry:

* Roughly shaped into irregular polygons
* Stones arranged - avoids vertical joints in face work.
* Also stone chips are used to support the stones.

Flint Rubble Masonry:



* flint & cobbles - irregular shaped nodules of silica.
* hard but brittle in nature
* thickness - 8 to 15 cm.
* length = 15 to 30 cm.

Ashlar
~~Brick~~ Masonry: * dressed stones, thk. of joints - 3mm.

Ashlar fine Masonary - uniform size & shape.
- Very costly

Ashlar rough - sides finely chisel - dressed
- Perimeter of the rough dressed face of each stone, a strip of 25 mm width is provided.

Rock & Quarry faced - wide - 25 mm, not dressed, rock facing
- Perimeter of the exposed face of every stone.
- ht. of each block - 15 to 30 cm.

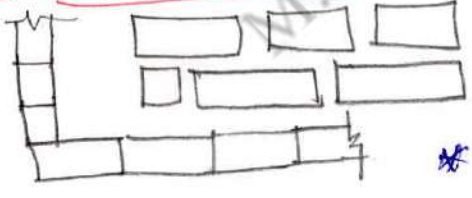
Ashlar Block in course :- intermediate b/w rubble & ashlar masonry, depth - 15 to 30 cm.
- heavy works - retaining walls, bridges. etc.

Ashlar chamfered masonry :
* ~~also~~ Rock-faced - Strip provided around the perimeter of the exposed face is chamfered or bevelled @ angle 45° by means of a chisel to a depth of 25 mm.

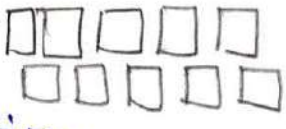
Brick Masonry : * Bricks bonded together with mortar.

Types :

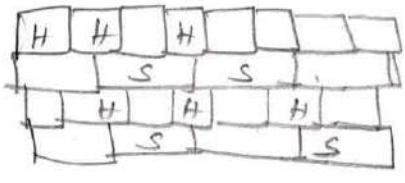
Stretcher bond : → Bricks laid on stretcher faces of wall. → Outer faced Cavity walls.



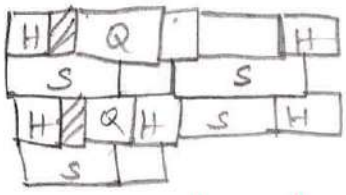
Header bond :
* headers on face of walls.
* Used - Construction of footings.



English bond :
* all wall thickness
* Strongest bond
* alternate courses of headers & stretchers.



Flemish bond: * Alternate header & stretcher & it starts with stretcher & followed by header.



~~Double~~ ~~Dutch~~ flemish — Single Flemish bond.

Raking bond: * bricks - laid any angle except Zero (or) ninety degrees. — Diagonal bond / Herringbone bond

Zig-Zag bond: * similar to herringbone bond.
* Zig Zag pattern

Stack Bond - * Bricks loaded on top of each other & held with mortar where all bonds are perfectly aligned * Not suitable transferring load

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 3 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Plastering & pointing, Cavity walls, Diaphragm walls.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Plastering:

* Process of covering rough surfaces of walls, columns, ceilings & other building components with thin coat of plastic mortar to form a smooth durable surface.

objective of plastering:

* To protect external surfaces against penetration of rain water
* To give smooth surface in which dust & dirt cannot lodge.
* To give decorative effect & protect against vermit

Requirements to good plaster:

* It should adhere to the background
* It should be hard & durable, good workability
* It should apply it during all weather conditions & it should be cheap.

Types of mortar for plastering:

Lime mortar:
* fat (or) hydraulic lime (1:3 to 1:4)
* Fat lime - preferred - good putty after slaking (1:2)
* Hydraulic lime - harder & stronger surface.
* Binding properties improved by adding gugal.
* Adhesive & tensile properties - mixing chopped hemp

Cement mortar: (1:4 to 1:6)
* best mortar - external plastering work, non-absorbant.
* Stronger than lime mortar.
* Dry mix + water - (within 30 minutes).

Lime-cement mortar:
Lime + cement => smooth plastered surface.
(1:1:6 - cement : lime : sand), (1:1:8) or (1:2:8)

Pointing:
* Applied to finishing of mortar joints in masonry.
* pointing depth - 10 to 20 mm & filling it with better quality mortar in desired shape.
  (i) Lime mortar (1:2 mix - lime : sand/Surkhi)
  (ii) Cement mortar (1:3 mix - Cement : sand)

Types of pointings:
* Flush pointings
* Recessed pointing
* Rubbed, keyed/grooved pointing.
* Beaded pointing
* Struck pointing
* V-pointing
* Weathered pointing.

Procedure : * Site logistic & slurry plant setup
* Pre-trenching
* Guide wall construction * Panel Excavation
* End-stop placement * Panel Descending
* Tremie concrete

Applications :
* As a retaining wall & cut-off provision to support deep excavation
* for a separating structure b/w major underground facilities & sheet piles in hydraulic structures
* intended to take up high vertical loads from above ground structures during construction

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Cavity walls: (or) hollow walls.

* Consists of two separate walls, called leaves or skins, with a cavity or gas in-between
* two leaves / skins - equal thickness.
* Non-load bearing wall - internal leaf thickness than external leaf. (4 to 10 cm)
* better thermal insulation to the building.

Purpose of cavity wall:

* Damp prevention
* thermal insulation
* Sound Insulation
* Efflorescence Prevention

General features:

* should extend to 15 cm below the damp Proof course level.
* wall ties - free from mortar droppings.
* In exposed conditions, few vertical joints in the outer leaf are left @ bottom - water drain

Advantages: * best for damp prevention 20%.
* heat insulators * construction cost - less

Disadvantages: * highly skilled labour & masons required
* vertical damp proof course is necessary.

Diaphragm wall / slurry wall:

* Creating Cast-in-situ reinforced concrete R.W using slurry supported trench method.
* Rigid, cost effective solution

Types of construction:

* Diaphragm wall (grabbed)
* Diaphragm wall (Cut)

Lecture No. 4 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Formwork, Centering & Shuttering, Shoring

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Formwork:

* temporary mould in which concrete is poured to cast the required shape of concrete.
* timber & steel - materials.
* some circumstances it may left in place (permanent framework).

Types of formwork:

* Timber, steel, Aluminium, plywood, Fabric & plastic formwork.

Adv:

Timber
* easy to form any shape, size & height
* economical for small projects
* light weighted

Steel:
* strong, durable & has longer life.
* smooth finish to the surface
* waterproof & moisture-proof.
* reused, fixed & removed

Aluminium formwork :

* Made from steel
* No alteration is possible once formwork is constructed
* light weight than steel.

Plywood formwork :

* re-moulded timber resin-bonded plywoodsheets
* strong, flexible & easy to handle.

Fabric formwork :

* New technology trends in building planning & designing.

plastic formwork :

* light weighted, have inter-locking systems & can be reused many times.

Centering and shuttering :

Centering :
* used to support horizontal members
* formwork for floor beams & slabs

Shuttering :
* support vertical members.
* formwork for columns, footings (or) retaining walls.

Requirements of Centering and Shuttering :

* Surface of the form should be smooth
* able to withstand all loads acting on it.
* able to retain shape.
* minimum deflection under load
* reusable & should not be costly.
* should be water-proof

Materials used :

Steel :

* thin steel plates & small steel angles used along the edges to stiffen these plates.
* clamps, nuts or bolts - used - to hold plates
* provides watertight formwork.
* can bear load coming on it easily.
* provides levelled surface of concrete.

Timber :

* cheap & easily available, it should be seasoned while using for shuttering
* light - weighted & should not have knots.
* should have smooth & even surface.

Important points considered :

* Size & thickness of planks may not be uniform. - do not have watertight joints.
* Surface of the RCC member can be even.
* If timber planks cannot bear the load of concrete on it, then deflection may occur in planks.

Temporary brick Masonry :

* Sometimes used in mud for the vertical supports of the beam sides.

* Temporary brick masonry should be avoided for the foll. reason.

→ Brick masonry soaks the cement slurry from the member. Thus, the strength of the member is greatly affected.

→ Brick Masonry formwork cannot bear the weight of Vibrator

→ An uneven surface of RCC member is obtained requiring more thickness of plaster.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 5 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	shoring – scaffolding – Underpinning.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

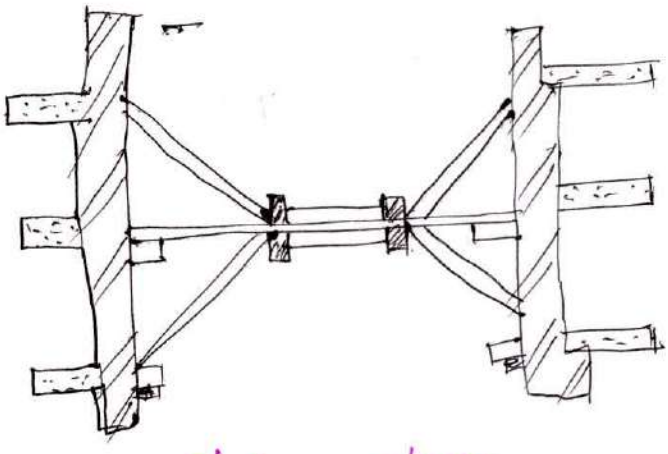
Shoring :

* Construction of a temporary structure to support temporarily an unsafe structure.

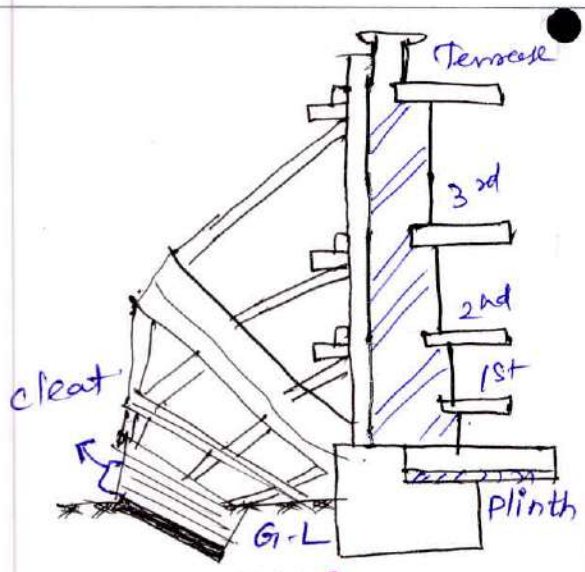
→ Raking
→ Flying
→ Dead / Vertical.

Raking Shores :

* Inclined members / rakers – give lateral support to the wall.
* Components – rakers / inclined members, wall plate, needles, cleats, bracing & sole plate (20 to 25 cm wide)
* inclined to the ground by 45°.
* tall buildings, length of raker can be reduced by introducing rider raker.
* centre line of wall should meet @ floor level.



Flying shore



Raking

Flying Shore :

* gives horizontal support to two adjacent, parallel party walls
*
* Struts – 45°; spacing – 3 to 4.5 m.

Singly fly → Double / compound flying

Dead Shores :

* consists of vertical members known as dead shores supporting horizontal members known as needles.
* To make large opening in existing wall at lower level.
* To rebuild / deepen the existing foundation.

Underpinning :

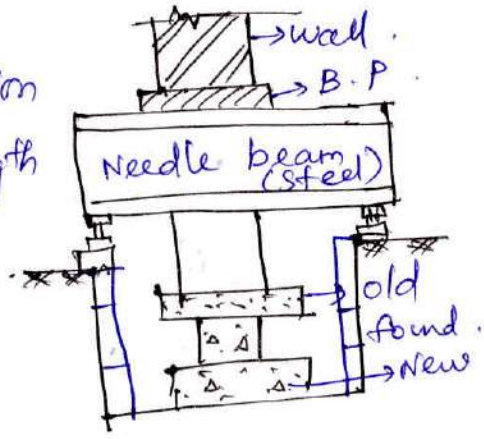
* Process of placing a new foundation under an existing one (or) strengthening an existing foundation

→ Pile method

↙ Pit method

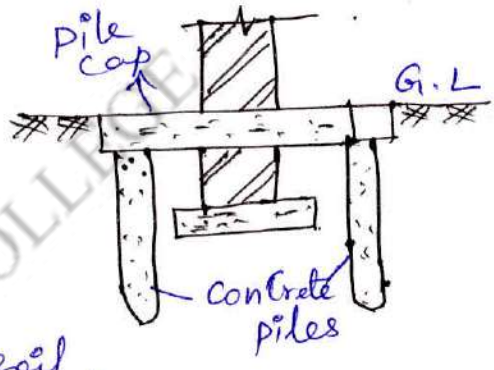
Pit method:

* entire length of the foundation to be underpinned – 1.2 to 1.5 m length
* Needles may be either of stout timber / steel section.
* The needle holes – should be closed using cement mortar.



Pile Method:

* Piles are driven at regular interval along both the sides of the wall.
* bore hole piles (or) under-reamed piles may be used.
* very useful in clayey soil.



Scaffolding:

* when the height of wall / column (or) other structural member of a building exceeds about 1.5 m, temporary structures are needed to support the plat form over which the workmen can sit & carry on constructions.
* ~~when~~ the temporary structures, constructed very close to the wall, is in the form of timber / steel framework, commonly called scaffolding.

Component parts:

* standards
* Ledgers
* Braces
* Putlogs
* Transoms
* Bridle
* Boarding
* Guard rail

Types of Scaffolding :

(i) Single scaffolding (or) brick-layers scaffolding
(ii) Double scaffolding / masons
(iii) Cantilever (or) needle scaffolding
(iv) Suspended scaffolding
(v) Trestle scaffolding
(vi) steel scaffolding
(vii) patented scaffolding.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 6 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Roofing — Flooring

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Roofs :

* Uppermost part of the building, provided as structural covering, to protect the building from weather.

Requirements of a roof :

* should have adequate strength & stability
* should protect the building against rain, sun, wind etc.
* should be water proof
* should be fire resistant, thermal insulation.

Types of roofs :

* Pitched / sloping (sloping top surface)
* Flat / terraced roofs [plain buildings (or) hot regions]
* Curved roofs (top surfaced curved → libraries, theatres etc)

Pitched roof : Basic Elements :

* Lean to roof
* Gable roof
* Hip roof
* Gambrel roof
* Mansard / Curb roof
* Deck roof

Types of pitched roofs:

* Single roofs — Lean to roof
  — Couple roof
  — Couple-close roof
  — Collar beam roof
* Double / purlin roofs
* Triple membered / framed or trussed roofs
  - King post roof truss
  - Queen post roof truss
  - Mansard roof truss
  - Truncated roof truss
  - Steel sloping roof truss.

Steel roof trusses:

* open trusses
* Bow string
* North light trusses
* Arched rib trusses.

Roof Covering for Pitched Roofs:

* Thatch covering
* Wood shingles
* Tiles
* Asbestos Cement sheets
* Galvanised corrugated iron sheets
* Eternit slates
* Light weight roofing.

Flat terrace roofing: * horizontal with Slope less than 10°.

Types: * Mud-terrace
* Mud-phaska,
* Brick jelly / Madras terrace
* Lime Concrete
* Bengal terrace.

d) Cement concrete flooring:
* Used - residential, commercial even industrial building
* cheap, durable & easy to construct
* Base course (7.5 to 10cm thick)

e) Terazzo flooring
* laid in thin layer over concrete topping
* very decorative & has good wearing properties
* chips proportion - 1 : 1 1/4 to 1 : 2

f) Mosaic flooring:
* made of small pieces of broken tiles of china glazed or of cement (or of marble arranged in different pattern.

g) Tiled flooring: - alternative to terrazo flooring

h) Marble flooring
* Marble slabs are cut to get marble tiles of 20 to 25 mm thickness.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Flooring :

* Permanent covering of a floor using any finishing material applied over the floor structure to provide walking surface.

Requirements :

* Adequate strength & stability
* Adequate fire resistance
* Sound proof
* Damp resistance
* Thermal insulation.

Types of flooring :

(a) **Mud / Muram flooring :**

* low cost housing - villages.
* form of integrated rock with binding material
* thickness - 15 cm, cheap, hard highly impervious.

(b) **Brick flooring :**

* cheap floor construction - godowns & factories
* thick - 7.5 cm.
* Sub grade - course brick laid flat in mortar is built.
* Brick layer is provided on sand bed(or) lean concrete (1 : 8 : 16) bed.

(c) **Flag stone flooring :**

* Laminated sand stones / slates of 20mm to 40mm thick in the form of slabs of 300 x 300mm (or) 450 x 450 mm.
* this type of works also called paving.

Lecture No. 7 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Joints in concrete – Contraction, Construction (or) Expansion Joints.

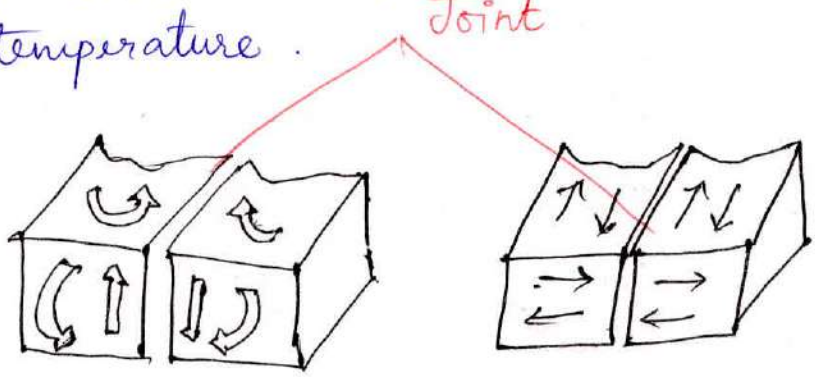
	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Joints :

* used to prevent cracks when the concrete shrinks by creating forming, tooling, sawing and placing joint formers.
* They prevent cracking of concrete.
* Concrete joints are used to compensate when concrete expands or shrinks with changes in temperature.



Types of Joints :

Contraction Joints :

* sawed, formed or tooled groove in a concrete slab that creates a weakened vertical plane.
* Unregulated cracks can grow and result in an unacceptably rough surface as well as water infiltration into the base, subbase & subgrade, which can enable other types of pavement distress.
* depth - 1/4 to 1/3, spaced at 3.1-15 m.
* Provided to allow the shrinkage movement in the structure.

Complete contraction joint
Partial contraction joint
Dummy contraction joint

Construction Joints :

* Key the two edges of the slab together either to provide transfer of loads or to help prevent curing (or) warping of the two adjacent edges.
* They must be designed in order to allow displacements between both sides of the slab but at the same time, they have to transfer flexural stresses produced in the slab by external loads.

* They must allow horizontal displacement right - angled to the joint surface that is normally caused by thermal & shrinkage movement.

Expansion Joint:

* depends upon the content of the change of temperature.
* These are provided when the length of the building is greater than 30 m & temperature changes by 50°C then a 10mm expansion joint is provided.
* It should be provided at the point where the structure changes in direction.

Joint Filler:

* Bitumen containing cellular material, rubber and thermo couple expanded plastic, mineral fiber & glass wool.
* tightly fitted in gap.

Sealing Compound:

* It's function is to seal, the joint against the passage of moisture and to prevent the ingress of dust grit, (or) other matter of the Joint. Mastic / hot bitumen & Silicon

Water Bar:

* The function of the water bar is to seal the joint against the passage of water.
* The water bar may be made up of rubber, GI sheet, copper & aluminium.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 8 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Fire protection, Thermal insulation, ventilation & Air conditioning

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Fire protection:

* The technical interpretation of fire safety of the building is to convey the fire resistance of buildings in terms of hours when subjected to fire of known intensity.

* ~~cover~~ Fire safety may be deemed to cover the foll. aspects.

→ Fire prevention & reduction of number of outbreaks of fire

→ Spread of fire, both internally & externally

→ Safe exit & fire extinguishing apparatus.

Causes of fire :

* Careless discarding of lighted ends of Cigarettes, matches & tobacco.
* incorrect storage of materials
* un-approved equipment & layout.
* faulty workmanship.

General fire safety Equipments for Buildings.

* All exits should be placed in such a way that they provide immediate access.
* electrical supply to the door may be cut off.
* False ceilings of the buildings shall be so constructed so as to prevent either total / early collapse of the

Fire Alarms & Fire Extinguishing Equipments :

* Manual fire extinguishing elements
* Fire Hydrant
* Automatic water Sprinkler.

Thermal insulation :

* used to indicate the construction / Provisions by way of which transmission of heat from (or) in the room is retarded.

Advantages : * Comfort * Prevention from condensation
* Fuel saving * Use of thermal insulating material.

Thermal insulating materials :

→ slab or block insulation
→ Blanket insulation
→ Loose fill insulation
→ Bat insulating materials
→ Insulating boards.

Ventilation :

* Heating, ventilation and Air conditioning (HVAC) System play an important role in buildings and homes.
* acts as lungs of the building.
* Ventilation circulates air from the outside into the building.

Types
- Natural
- Mechanical
- Hybrid.

Air conditioning :

* Process of giving comfort to the occupant in a particular space irrespective of any external climatic conditions.
* Treatment of indoor air in order to control certain conditions required for human comfort.

Classification.
- Comfort air conditioning
- Industrial Air conditioning

Equipments used for air-conditioning :
* Air circulation fan
* Air-conditioned Supply duct
* Supply outlet (grill)
* Return outlet duct
* Filter

Factors affecting Air - Conditioning :

* Temperature
* Humidity
* Air motion.

Types of Air Conditioning :

* Window air - conditioning system
* Split air - conditioning system
* Package air - conditioning system
* Centralized air - conditioning system.

Advantages :

* Filters of air, improving air quality
* Dehumidifies the ambient air.

Disadvantages :

* Skin may get affect
* AC creates some ambient noise
* Increase in electricity bills.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 9 UNIT III – CONSTRUCTION PRACTICES & SERVICE REQUIREMENTS

Topic(s) to be covered	Acoustics & Sound Insulation, Damp proofing.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Acoustics and Sound Insulation:

* Acoustics – science of sound, which deals with origin, propagation & auditory sensation of sound & also with design & construction of different building units.
* planning of structural elements, to make them sound proof is one of the consideration.
* Sound Insulation – is a kind of measure to prevent the sound waves from ~~pre~~ permitting.

Factors affecting Acoustics of Buildings:

* Site selection
* Volume & shape of building
* Interior spaces and planning.

Acoustics properties of Building Materials :

* It is always necessary to have a Pre-planning mainly for the building Constructions that are prone to noise disturbances.
* Acoustic properties of Masonry, Concrete (or) stone materials
* Acoustic properties of Wood & Related Products
* Acoustic Properties of steel
* Acoustic properties of Glass & Transparent Materials
* Acoustic Insulating materials.
* Acoustic properties of Rubber & plastic.

Advantages :

* Acurate sound frequency & intensity
* Privacy of space is maintained without any disturbance
* More carpet area can be utilized with Proper planning & designing.
* In auditorium, acoustic planning results in evenly distribution of sound, seating arrangement contributes to absorption of sound, uneven thickness of wall surfaces results in reflection of sound.

Damp proofing in Buildings: (DPC)

The DPC is generally applied at basement levels, which restricts the movement of moisture through walls & floors.

Dampness is the presence of hydroscopic (or) gravitational moisture in the building.

The causes of dampness may be,

→ Moisture rising up from the ground to the walls

→ Rain water travel from wall tops

→ Condensation

→ Rain showers against external walls.

Three categories:

* Flexible Materials
* Semi-rigid Materials
* Rigid Materials

Selection of Materials for damp proof course in Buildings:

It depends upon the climate & atmospheric conditions, nature of the structure & the situation where DPC is to be provided.

Methods of Damp proofing:

* Membrane damp proofing.
* Integral damp proofing
* Surface treatment
* Cavity wall construction

* Guniting
* Pressure grouting.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 1 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of equipment for earthwork excavation.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Construction Equipments :

* It is an integral part of any Construction process.
* Selection of appropriate type & size of Construction equipment depends on the required amount of time and volume of work to be done.
* Proper use of these equipments – ~~boods~~ Contributes to economy, quality, safety, speed & timely completion of the project.
* Used – excavating, concreting, loading & unloading materials, driving materials, site clearance.
* Dewatering – one of the biggest challenges faced in construction industry.

* Improper dewatering – cause loss of money and time.

*

Equipment

- Earthwork excavation
  - * Excavators
  - * Loaders
  - * Scrappers
  - * Graders
  - * Dozers
  - * Trenchers
- Concreting
  - * Batching plant
  - * Mixers
  - * pumps & pipeline
  - * Vibrators
  - * shotcrete gun
- Material handling / Erection
  - * Hoists
  - * conveyors
  - * Cranes
  - * Trucks
- Dewatering / Pumping
  - * Centrifuges
  - * Vaccum filters
  - * Drying beds
  - * filters presses
  - * Sludge lagoons
  - * Pumps

Earthwork Equipments:

* wide range of excavating equipments are available in construction industry.
* Requires much greater care & consideration in selecting the most suitable machine for a particular job.
* Foll. factors need to be considered while selecting excavating equipment,
  - → Nature of work
  - → Method of operation
  - → Duration of the job.
  - → Machine specification.
  - → Installation & operation costs
  - → Maintenance & spare costs.

The different types of earthwork equipments are as follows.

(i) Excavators :

* heavy construction equipment consisting of boom, arm, bucket & cab on a rotating superstructure.
* Uses - digging purposes as well as various lifting & carrying tasks.
* Based on size & working type. excavators are classified as follows;

Compact Excavator :

* tracked / wheeled vehicle weight (0.7 to 7.5 tons)
* Standard backfill blade & independent boom swing.
* Hydraulic excavators - hydraulic fluid acting upon hydraulic cylinders.
* Excavators slew (rotation) & travel functions are also activated by hydraulic fluid powering hydraulic motors.

Crawler excavator :

- mini - crawler (fit every job)
- Heavy crawler. (hardest working excavators)

Wheeled Excavator :

* easily navigate streets & hard surfaces.
* Low effort levers deliver smooth rolom boom & bucket control

Backhoe excavator : /excavator.

* Shortened to backhoe, heavy equipment vehicle - tractor fitted with a shovel / bucket on the front & a small backhoe on the back.
* building a small house, fixing urban roads, etc.
* Crowd power, swing torque & boom & dipper stick lift.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 2 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of equipment for earthwork excavation.

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Dragline excavator:

* heavy equipment – civil engg & surface mining.
* smaller type – road & port construction
* Large type – Stripping operations to more overburden above coal & tar sand mining.
* weight – 2000 metric tons
* large bucket – boom with wire ropes

Long Reach

* long boom arm → demolition.
* demolish & pull down the structure in a controlled fashion.

Suction Excavator:

* Removes earth from a hole on land (or) removes heavy debris on load.
* Suction inlet air speed – 100 m/sec

Power shovel: /stripping shovel / front shovel / electric shovel.

* bucket equipped machine, electrically powered → uses → digging & loading earth (or) fragmented rock & for mineral extraction.

(ii) Loaders:

* heavy equipment machine, to load materials such as excavated earth, sand, rock, gravel, asphalt, demolition debris, logs etc.

Backhoe Loaders –

* Mostly in construction sites; loading bucket at the front - to dig the materials directly.

Skid Steer loaders:

* excellent for light work & a fast-paced job site.
* Four-wheeled tools - steer by skidding.

Crawler loader:

* Loading bucket onto a crawler tractor.
* capable of maneuvering across the entire construction site under its own power, ~~whereas~~

* Wheel loaders:

* shoveling large volumes in a short time
* they have latest technology & built-in toughness to work in the most challenging applications.

Types – compact wheel loaders, small wheel loaders, medium wheel loaders, large wheel loaders.

(iii) Scrapers : * earth moving in construction, mining & agriculture industries

* used to remove layers of earth across a vast area of land.

* have very large rubber tires & motorized.

Single Engine wheeled scrapers.

* bowl, an apron, an ejector.

Dual engine wheeled scrapers:

* For terrains that are little tougher than your average job site, this is used.

* two engines

Elevating scrapers:

* uses an elevator that is either hydraulically (or) electrically driven.

* load materials into a raised bowl that can then dump out a load by sliding the bowl's floor backwards.

(iv) Graders:

* Road grader, a blade, a maintainer (or) a motor grader with long blade used to create a flat surface.

Rigid frame motor graders (Smaller construction spaces) Articulated frame.

Small motor graders

→ landscaping jobs, road maintenance.

Large motor graders:

→ highways & motorway construction.

(v) Dozers :

* Pushing, digging, excavating & levelling materials (soil & debris)
* heavy blades, rippers.

→ Straight blades, Angle blade, Universal Blade, Semi-U blade, Crawler bulldozers, Wheel Bulldozers, Mini bulldozers.

(vi) Trenchers : (or) ditchers.

* similar to excavators - penetrate earth, breaking soil & rock & remove it from ground.
* metal chain with teeth made of high-strength steel.
* clean trench with a flat bottom & smooth walls.

→ chain trenchers, wheel trenchers, Micro trenchers.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 3 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of equipment for ~~concreting~~ Concreting.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Concreting Equipments:

* very much significant for the construction field.
* Using this, quality construction can be attained in a lesser measure of time.
* lessen the risk of human error.
* finish projects much faster.

(i) Concrete Batching Plant:

* mixes various materials to form concrete (sand, aggregate, slag, cement, fly ash & water)
* comprises - adequate capacity gravel, sand hoppers, weighing conveyor, reversible drum type mixer unit, cement bin.

* Concrete batching plants come in various type;
  * Dry mix concrete plant
  * Wet mix concrete plant
  * Mobile concrete plant
  * Stationery concrete plant.
* Mobile plants - used by temporary site projects & projects that don't require much concrete.
  * Large building, ports, bridges, tunnels & dams
  * can be used wet (or) dry.
  * Ready Mix, Precast & Prestressed, Central Mix & RCC, Mobile concrete Batching.
* Stationary concrete batching - rise in demand and manufacturers are modifying new models based on customer needs.
  * twin shaft mixers for maximized capacity
  * Capacities => 30 m^3 to 240 m^3 per hour of compacted concrete.
  * aggregates stored in - horizontal bins
  * aggregates discharged onto the charging conveyor.
  * Discharge of aggregate - gathering conveyor.
  * comes with Skip hoist & belt arrangement option for mixer loading & a modular PLC-based control systems.

(ii) Concrete Pump :

* Fastest concrete equipment which is significant in the construction industry because of its reliability & cost-effectiveness.
* Concrete pump - used to transfer Concrete from the production to the casting area.
* One piston - drawing concrete from source & another piston - Pushes it into the discharge pipe.
* Saves labor cost, time & material with high power consumption.

- line pumps
- boom concrete pumps

line pumps

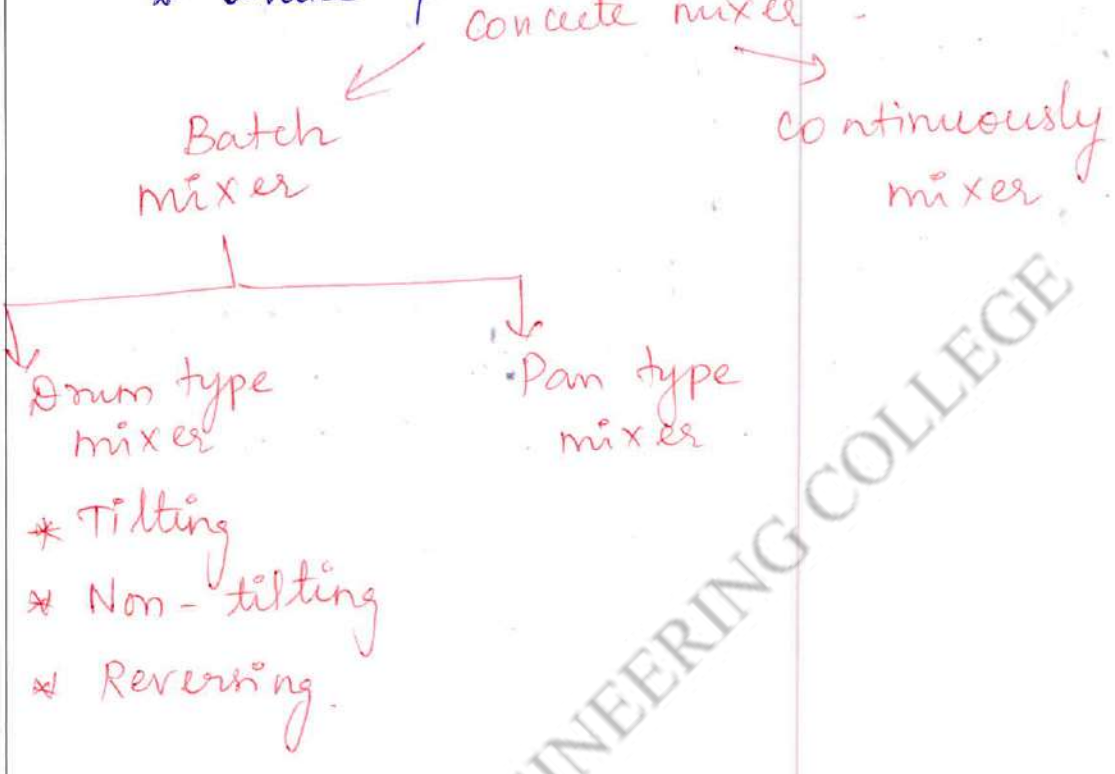
* Mounted on a truck & placed on a trailer.
→ Pump concrete @ lower volumes than boom pumps.
→ sidewalks, small constructions, mostly ground slabs.

Boom concrete pumps :

→ Attached to a truck & use a remote-controlled articulating robotic arm.
→ used on big construction sites
→ Pump @ very high volumes, as it can pump in different heights & leyths
→ multi-level buildings & bridges

(iii) Concrete mixer :

* mixes cement, aggregates & water mechanically.
* whole production line.



Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 4. **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of Equipment for concreting.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Batch concrete mixers :

* widely used machines in concrete mixing.
* mixer is collected batch by batch and time by time

- **Drum type** (mixed in a drum which is in double conical frustum shape)
  - → Tilting drum mixers
  - → Non-tilting drum mixers
  - → Reversing drum mixers.
- **Pan type** (circular pan)
  - → two type of pan mixers
  - → Rotating star blades and static star blades.

Tilting drum mixer :

* discharge concrete by tilting downwards
* Rapid discharge process & used for larger projects.
* Mixing efficiency depends on the shape of the drum, angle of drum & size, angle of blades.
* disadv - sticking of concrete @ bottom of drum

Non-Tilting drum mixers :

* Not allowed to tilt & the drum rotates about its horizontal axis.
* Discharge of concrete - inclined position
* drum is opened at two ends & contains blades inside the drum for mixing.
* Rapid discharge of concrete is not possible in this case.
* Vulnerable to segregation - small projects used

Rerverse drum mixers.

* similar to non-tilting types but reversal of rotation takes place for different action.
* Two openings, drum rotates - horizontal axis
* Two diff. set blades arranged.

~~Continuous Pan type~~ Concrete mix :

* mixer, loading, mixing & discharging of mix is continuous until the work is complete
* high rise buildings, dams, bridges, etc.

(iv) Concrete Vibrator :

* Mechanical device used to create vibration in wet concrete to compact the concrete.
* Removes all air in between the concrete mix.
* small civil work to large construction.

Internal Vibrator / Needle :

→ steel tube with one end closed & rounded, having an eccentric vibrating element inside.
→ size (40 to 100 mm dia)
→ frequency of vibration varies upto 15000 rpm
→ vibration period (30 seconds to 2 minute)

External or Shutter Vibrators :

→ vibrators clamped tightly to the form work at the pre-determined points so that the form & concrete are vibrated
→ frequency of vibration (3000 to 9000 rpm)
→ can't be compacted by internal vibrators.

Surface Vibrators :

→ placed directly on the concrete mass.
→ should not be used when the depth of concrete to be vibrated is more than 250mm
→ very dry mixes can be most effectively compacted with surface vibrators.
→ patching & repair work of pavement slabs.

Table Vibrator :

→ Rigidly built steel platform mounted on flexible springs & driven by electric motor.

→ frequency - 4000 rpm.

→ precast elements in factories & test specimens in laboratories.

Shotcrete Equipments :

* Used for concrete spraying applications at the construction sites.
* force of spraying action leads to compaction of the concrete
* needs less formwork & most cost-effective than traditionally placed concrete
* wet (or) dry mix process.
* Lining of water tanks, mines, swimming pools, backfilling of tunnel construction.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 5 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of equipment for material handling & erection of structures

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Material handling equipments :

* Material handling – loading, moving, & unloading of materials.

* To perform the action safely & economically, diff. types of tackles, gadgets and equipments are used, which are called as material handling equipments.

Essential requirements ;

→ efficient & safe movement of materials to the desired place.

→ Timely movement of the material when needed.

→ Supply of materials at the desired rate.

→ Storing of materials utilizing minimum space.

→ Lowest cost solution to the materials handling activities.

Types:

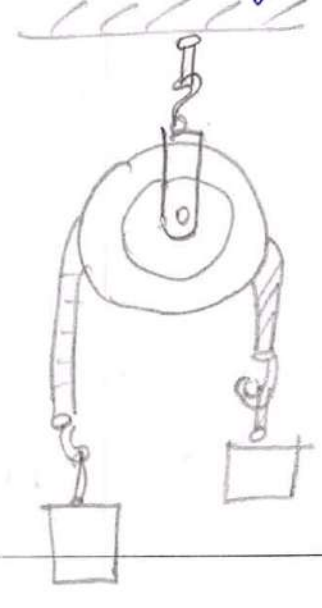
* Hoists
* Conveyors
* Cranes
* Trucks

(i) Hoists:

→ device for raising or lowering a load by means of a drum (or) wheel lift to which wraps the rope or chain.

→ Can be operated by hand, electrically (or) pneumatically. chain (or) wire rope fibres.

→ load connected to the lifting means of a lifting hook.



Pulley :

* It is a wheel on an axle (or) shaft that is designed to support movement & change direction of a cable (or) belt along its circumference.
* Uses - lift loads, apply forces & to transmit power.
* The assembly of a wheel, axle, & supporting sheel is referred to as "block"
* Pulley - also called as sheave (or) drum & may have groove b/w two flanges.
* Alloy chains are best suited for hoisting operation.
* Once hook gets elongated / straightened it should be replaced.

Chain hoist :

* Popular mechanism for lifting loads of upto tonnes.
* 2 sets of chain - hand & load chain.
* Load to be lifted is held by a load hook while another hook (called support hook) at the top, support the mechanism.
* Two hooks, should not be interchanged, as the support hook is made much stronger than the load hook.

4 types of hand-operated chain hoists - Differential, Screw geared, Spur geared, pull lift.

Winch :

* It is a rotating pool, driven by a motor that can tighten or loosen a cable.
* hook at the end of cable.
* A winch is a mechanism in the shape of a cylinder or drum, over which rope or chain is wound.
* Used for raising & lowering, sometimes referred to as hoist.
* Two types

hand winches → power winches.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 6. **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of equipment for material handling & erection.

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Conveyors :

* Useful for moving material b/w two fixed workstations, either continuously (or) intermittenly.
* Used – Continuous (or) mass material handling operations.
* Various types - rollers, wheels (or) belts to help move the material along & may be power-driven (or) may roll freely

* Types
  - → Belt Conveyors
  - → chain Conveyors
  - → Cable Conveyors
  - → Roller Conveyors
  - → Screw Conveyors
  - → Chute Conveyors

Belt Conveyors :

* Consists of an endless flat & flexible belt of sufficient strength, made of fabric, rubber, plastic, leather or metal, which is laid over two metallic flat pulleys at two ends.
* Moving belt is placed for transportation.
* The endless belt is kept tight by a belt tensioning arrangement.
* Types — Flat belt,
  Troughed belt,
  Closed belt,
  Metallic belt.

Chain conveyors :

* Group of different types of conveyors used in diverse applications, characterized by one (or) multiple strands of endless chains that travel entire conveyor path
* The load carrying chain is generally supported on idle sprockets or guide ways.
* Different types of chain conveyors are Apron (or) pan conveyor & Cross-Bar or Arm conveyor.

Cable Conveyors :

* To transport people & bulk materials in load carrying buckets, using overhead moving cables / wire ropes. — Several kilometers.
* these Conveyors are also known as ropeways or aerial tramways.

Roller Conveyors :

* Series of rollers, mounted on bearings, resting at fixed spacings on two side frames which are fixed to stands or trestles placed on floor at certain intervals.
* Rollers, ingots, plates, rolled stock, pipes, logs, boxes, crates, moulding boxes etc.
* Two types

- Unpowered (or) Idle Roller Conveyor
- Powered (or) Live Roller Conveyor.

Screw conveyors :

* consists of continuous or interrupted helical screw fastened to a shaft which is rotated in a U-shaped trough to push fine grained bulk material through the trough.

* It is suitable for any pulverized (or) granular non viscous material
* It is not suitable for large - lumped, Packing or sticking materials.

Chute conveyors :

* least expensive methods of Conveying material.
* chutes are Inclined connections b/w two systems of material handling equipment or production equipment, in the form of troughs of definite geometrical cross section or pipes, which convey unit or bulk load by gravity.
* Depending on the load to be handled, chutes are made of various size, shape & material.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 7 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Selection of equipment for Material handling & erection.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

(iii) Cranes :

* A crane is a piece of heavy machinery that is a tower or platform that is equipped with cables and pulleys.
* They are used to lift and lower materials.
* Mostly commonly used cranes are;

→ Derrick Crane, Mobile Crane, Crawler Crane, Rough Terrain Crane, Truck Mounted Crane, Telescopic Handler crane Tower Cranes, overhead / Granty Crane.

Derrick Crane : — Stiff leg derrick
— Guy derrick.

* It is a special type of crane in which the distance from the end of the jib to the pillar can be changed.

Mobile cranes :

* Most basic type of crane & consists of a steel truss (or) telescopic boom mounted on some kind of mobile platform.

Crawler Crane :

* Track vehicles .. Instead of wheels, crawlers are built on an undercarriage fitted with a pair of rubber tracks.

Rough Terrain Crane :

* It is built similarly to a crawler crane, but instead of tracks, the undercarriage is outfitted with four large Rubber tires that are typically equipped with 4-wheel drive.

Truck Mounted Crane :

* These types of cranes are mounted on a rubber tire truck & provide excellent mobility. 2 parts : the carrier (truck) & the boom (arm).

Telescopic Handler Cranes :

* They are equipped with a boom (arm) outfitted with a hydraulic cylinder that allows it to change length, like a telescope.

Tower Cranes :

* Usually, they are fixed to the ground in concrete base or attached to the side of structures.

Overhead / Gantry Cranes :

* They are indispensable machine in factories, workshops. also known as Suspended cranes.

(iv) Trucks :

~~Non-powered truck.~~
Powered truck.

* It is one of the most common group of materials handling equipment used in industry as well as in day to day distribution of goods in warehouses, large stores, etc.

Hand trucks:

* No source of motive power, these are generally moved manually or are attached to other powered moving equipment.
  - → Two wheel hand truck
  - → Multiple-wheel hand truck
  - → Hand lift truck

Powered trucks:

* when a vehicle / truck contain its own source of motive power
  - → mode of action
  - → power source
  - → type of wheel
  - → mode of control
  - → height of lift
  - → mode of travel.

The powered truck can be divided into

- Fortlift Trucks
- Tractor
- Dump truck.

Fork lift trucks :

* These are most versatile, useful & widely used equipment as industrial lift trucks.
* Capacity (1 tonne to 60 tonnes).

Tractor :

* It is a vehicle, having its own source of motive power, used as a prime material handling equipment.
* 2 types – crawler tractors & wheel tractors.

Dump truck :

* Also known as tipper truck, used for hauling sand, gravel, excavated earth, bituminous aggregate in construction industry.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 8 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Dewatering / pumping Equipments

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Dewatering / pumping Equipments :

* These equipments are used to perform dewatering on construction sites, which is defined as the process of separating water from another material like saturated soil or sludge.
* This saves money by reducing solids handling and disposal expenses.

Dewatering Methods :

Sump pumping :

* In this method of dewatering, water is disposed by adjusting the pump of the trench.
* Centrifugal pumps are generally used.
* Used for shallow bases in water logged areas.

Deep well construction :

This method of dewatering is more suitable when digging operation is lower than water table or artesian water present in soil.

Wells work best in soils consisting of sand, or sand & gravel mixtures & can dewater large areas to great depths.

Freezing methods of dewatering :

In this method, large pipes of 10 to 15cm diameter are laid in the ground around the area where excavation is to be done.

Coldwater escapes from a small pipe & climbs up into a large pipe & returns to the refrigeration plant.

This cold water freezes the moist soil & forms a wall of frozen clay.

well points :

In this method of dewatering the ground water flow is diverted into deep well points in the ground & the part to be excavated is kept free from ground water.

well point systems may be

Single stage (or) Multiple stage.

Single Stage System :

* Water can be lifted from a depth of 5m with a suction pump.
* This plant is not disturbed until the excavation work is completely completed.

Multiple Stage System :

* When excavation depth is more than 5m below ground water level.
* The sides of the excavation are given a proper slope.

Cement grouting :

* Cement grout is a mixture of cement, sand and water.
* holes are made – cement grout is inserted into each of these holes.
* Cement grout freezes in stone Cracks and clay cavities, making the stone or clay water-tight & monolithic.
* waterproof layer is formed by forcibly inserting grout into the soil around the channel.
* And that way the springs of water in the base trenches can be stopped.

Chemical consolidation of soils:

* In this method of dewatering, the soil around the area to be excavated is hardened with a solution of chemical compounds like silicate of soda and calcium chloride.
* In this method also, pipes are lowered into the ground.
* The chemical reaction b/w two chemicals makes the soil hard.
* This method is very costly.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 9 **UNIT IV – CONSTRUCTION EQUIPMENTS**

Topic(s) to be covered	Dewatering Equipments.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Dewatering Equipments:

* Equipment to be used will depend on the corrosion potential of the material, such as sludge, to be pumped, hazardous contaminants & so on.
* Different types of dewatering equipment;

Centrifuges	Centrifugal pumps
Vacuum filters	Displacement pumps
Filter Presses	Submersible pumps
Drying beds	Air lift pumps.
Sludge lagoons	

Centrifuges:

* Separate solids from liquids through sedimentation and centrifugal force.
* The sludge moves with acceleration through the ports in the conveyor shaft, which is then distributed to the periphery of the bowl.

Vaccum filters :

* They involve creating a vaccum to draw out water from solids.
* steps - digestion or heat treatment before disposal, incineration or usage.
* When the drum carries the sludge to the atmosphere, the cake layer formed is chipped by a knife blade.

Filter presses :

* They use a porous press to separate solids from liquids.
* This equipment uses a filter medium to separate solids from liquids. A filter press captures the solids in the pores b/w two or more porous plates.

Drying beds :

* They consists of perforated or open joint drainage pipes laid within a gravel base.
* Cracks develop as the sludge dries, allowing evaporation to occur from the lower layers which accelerates the drying process.

Sludge lagoons :

* They are excavated areas in which digested sludge can be deposited and dried for several months to a year or more ; Depth (2 - 6 ft).
* Since lagoons require only the necessary land area & excavation equipment, they are operationally inexpensive.

* Pumps simply remove liquid from a volume of liquid, whereas dewatering equipment separates water from another material such as soil or sludge.

Uses:

→ To keep water out of foundations, pits, tunnels, & other excavations.
→ To pump water out of cofferdams.
→ To drying solids and foundation grouting.

Choice of pumping equipment depends on;

→ The type of liquid to be pumped
→ The amount of liquid to be moved.
→ The height of the suction lift - distance from the water to the pump.

Centrifugal pump:

* This contain a rotating impeller which creates a vortex that sucks air out of the hose.
* Self - priming pumps have a reserve supply of water in the impeller chamber.
* Air - operated centrifugal pumps - 'Sump pumps'.
* Used - in tunnels & foundation pits

Displacement pumps:

* They can be either reciprocating or diaphragm pumps.
* Reciprocating pumps work by the action of a piston or ram moving in a cylinder.
* Diaphragm pumps work by drawing water into a cylinder in which a flexible diaphragm is raised & lowered.

Submersible pumps :

* They can be used for lowering groundwater (or) removing water from a deep sump.
* Pump – consists of centrifugal unit & motor mounted in a single cylindrical unit with a space b/w pump & casing
* Uses – heavy duty work that involves lifting gravity water.

Air lift pumps :

→ consists, not of moving parts, but of a long vertical pipe connected to a supply of compressed air.

→ Air lift pumps are often used for moving silt from the base of a coffer dam.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 1 **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	Introduction to Construction planning

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Construction planning:

* Construction planning is an important step when constructing a structure because it summarizes the project and provides guidelines to complete the project in a successful manner.
* A construction plan defines the scope of work, sets timelines, allocates resources, establishes Communication protocols.

Necessity for construction planning.

* Planning is the most important technique of the management.
* planning means preparation for the future.

* Construction planning project includes the estimate, budget, time schedule, sequences of completion of each activity of the project, resource & manpower planning.

Classification of construction projects.

Building Projects:

* providing shelter, services for habitation, educational, recreational, social & commercial needs.
* designed by engineering firms & financed by Governments, public & private sectors.

Infrastructure Projects:

* Use of large quantity of bulk materials like earth, steel and concrete.
* dams, canals, highways, airport, railways & bridges.

Industrial Projects:

* Steel mills, petroleum refineries & many other
* heavy investment

Special purpose projects:

* include projects for protecting the environment, utility service complex operations.

Steps in the Construction planning:

(i) project initiation:

→ First step - to find out the problem or identify the opportunity to be seized.

→ Project Initiation document (PID)
(no. of workers needed, contractors & subcontractors
Materials, Total cost estimate - labour, material, equipment)

(ii) Creating the project plan.

* Creation of project plan.
* The project initiation document turns into a more concrete construction plan by setting goals that are S.M.A.R.T

S. M. A. R. T → Timely.
→ Realistic
↙ ↓ ↘
Specific Measurable Attainable

(iii) Executing the plan:

* Team meetings should be arranged frequently to discuss about the project plan & construction schedule.
* To narrate the expectations from manager & their queries if any should be answered.

(iv) Tracking the project progress:

* ~~thee~~ Ensures that the milestones are completed.
* Key performance indicators (KPIs) to monitor the performance of their projects

Project objectives ← KPI → Time schedule.
↓ → Quality of Construction
project performance

(v) Evaluation of the project:

* The lessons learned and data gathered from the project will help to approach the next project in a consecutive manner.
* This work will serve as the pre-construction planning for the next project.

Objectives of construction planning:

* Each element of the project should be properly designed.
* Selecting proper equipment & machinery
* Proper maintenance facility
* Procuring materials well in advance and stocking at the site
* Employing well trained & experienced staff.
* Providing welfare schemes for the staff & workers.
* Ensuring proper safety measures for the workers such as proper Ventilation, proper arrangement of light & water.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 2 **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	Construction planning construction scheduling

	Lecture Outcome (LO) At the end of this lecture, students will be able to	Bloom's Level

Teaching Learning Material	Student Activity

Lecture Notes

Principles of Construction planning:

* plan should be realistic, flexible and comprehensive
* Phan should provide a source for project monitoring and control process.

Types of construction project planning:

Strategic planning:

* The project manager meet with Corporate planners & the client to determine the requirements & expectations.
* After collecting data, the project manager creates a master construction delivery plan with specific guidelines to ensure the team completes the project on time.

Operational planning:

* The project teams come together to expertise a detailed plan with strategic goals & activity steps.
* They agree on deadlines & work together to complete documents with reports

Business planning:

* Describes the project & includes a chart of what the project should look like.

Resource planning:

* Creating a resource plan ensures that each project a company is currently working has sufficient staff, materials & resources.

Stages of construction planning:

→ Preplanning
→ Detailed planning
→ Monitoring & control

Advantages of construction planning:

* Sequence of work, detailed sketches, bar charts etc.
* maintain cash flow.
* Labour requirement can also be managed.
* Various sub activities of the project can also be identified.

Limitations of planning:

* Effectiveness of the plan depends upon the correctness of assumptions.
* Certain big project - expensive.
* planning encourages a false sense of security.

Construction scheduling :

* Can be defined as the process of listing all the activities to be carried out with the planned start and completion dates.
* The schedule outlines project milestones and tracks project progress to keep everything on time & on budget.
* It's the backbone of a successful project management for construction.

Step involved

① Project no. of operations & sequences

② quantity of work.

③ time required for completion.

Classification of scheduling :

Construction scheduling

Resource Oriented

* one of the most thoughtful construction scheduling methods
* identify resources available & utilizing them efficiently to avoid wastage.

Time Oriented

* determination of completion of the project with the given relationship.
* scheduling software is time-oriented.

Types of construction schedules :

* Construction Material schedule
* Labour schedule
* Equipment schedule
* Financial schedule
* Control schedule
* Organization schedule
* Summary schedule.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 3. **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	Construction scheduling

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Methods of scheduling:

→ depends upon the nature of the project.

Methods of scheduling,

* Gantt chart
* Q scheduling
* Last planner system
* Line of Balance
* Work breakdown structure
* Critical path Method (CPM)
* Program Evaluation and Review Technique (PERT)

Gantt chart:

* Henry Gantt, an American Mechanical engineer, designed the Gantt chart.
* Utilizes the bar chart to depict the plan and the progress of the project.
* helps in scheduling, managing & monitoring specific tasks & resources in a project.
* This chart shows project timeline, including managers in communicating scheduled.

Q - scheduling :

* Quantitative scheduling, Q scheduling
* Uses - bar charts to visualize resources quantities and the location in which the resources will be used.
* focuses on materials & equipment used in the project.
* provides support against delays due to improper material management.
* least Common methods used in Construction.

Last planner system :

* unique scheduling method.
* bridges gap between the team or workers.
* Also termed as pull planning
* This system follow schedule efficiently and Complete the project on time
* strong Collaboration & backward timeline

Line of Balance : (LOB)

* usually implied in projects that include repetitive activity.
* measures the cost, time & project completion plan & ensures nothing falls behind the schedule.
* most commonly used for roadways, pipes and other horizontal construction projects.
* It shows process, status, background timing & phasing of the project activities.

Scheduling with LOB:

* Prepare a logic diagram
* Estimate the man-hours required to complete each operation
* Choose buffer times which will guard against the risk of interface between operations.
* Calculate the required output target in order to meet a given project completion date
* Complete the LOB schedule.
* Examine the schedule.

Advantages:

* Better understanding of the amount of work taking place at a certain time in a specific place.
* Optimized resources for a large number of repeated work activities.
* Allows easier cost & time optimization analysis.
* Easy to modify, update & change the schedule.
* Better management of sub contractors and resources.
* Identifies issues in advance.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 44. **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	Scheduling for activities

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

Work break down structure :

* Work breakdown structure (WBS) is a tool that is used to record and communicate the project deliverables and sub-deliverables as well as the accomplishments and sub-accomplishments
* The process of breaking the project into easily indentifiable major systems, their sub systems and breaking the project discrete activities are is called break down structures.
* It is helpful diagram for project managers.
* indicate the tasks, deliverables & work packages

Types of WBS

- Deliverable based
- Phase based.

(i) Deliverable - based WBS :

* breaks down projects into all major areas of the project scope — control accounts, ↓ project deliverables & work packages.
* Construction specialists favour of deliverable oriented / product oriented.
* WBS - revolves around tangible deliverables
* Interim deliverables - include plan & specifications

Advantages :

* Simplifies the process of cost estimating.
* Can be used during all project phases.
* Supports earned value management.
* easier to modify as the project changes.

(ii) phase - Based WBS :

* focuses on the processes you require to achieve the deliverables.
* This kind of document also known as process - Oriented, task - oriented (or) activity - oriented work breakdown structure.
* Graphical representation - chronological order
* project schedule network ~~diagraphm~~ diagram
* consists of boxes & arrows indicates the flow of work.

Types of WBS schedule:

* Work break down structure list
  - also termed as an outline view
  - list of work packages, tasks & deliverables
  - simplest method
* Work Breakdown structure Tree diagram
  - Phases, deliverables, tasks and work packages - diagrammatic representation
* Work breakdown structure Gantt chart
  - spreadsheet and a timeline
  - Links dependencies and set milestones or baseline.
  - most common version in project management software.

Steps to create a Work Breakdown Schedule:

1. Define the project scope, Goals and objectives - documented in project charter
2. Identify project phases & control Accounts
3. List the Project deliverables (work packages, resources, participants etc)
4. Set WBS levels - hierarchical deconstruction of project work.
5. Create Work Packages ↳ Split - single task & subtask.
6. Choose Task owners ↳ project team
7. Critical path method
8. Program Evaluation and Review Technique (PERT)

Uses of construction scheduling:

* information - quantity of work, labour, machinery, equipment
* Progress of work & the expenditure can be checked & duly adjusted
* Project can be completed systematically and effectively.

Advantages of construction scheduling:

* Various phases of work execution can be listed and duly procured thereby preventing the shortage and overbuying of resources.
* work progress can be well monitored and evaluated
* prevents undue delay & extension of time
* helps to complete the entire project within the planned approved budget preventing cost overrun.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books			
S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 5. **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	CPM and PERT Network Modelling and Time analysis.

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

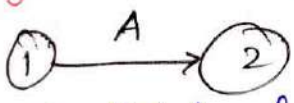
Lecture Notes

CPM & PERT Network Modelling and Time Analysis :

* A convenient analytical and visual technique of CPM & PERT prove extremely Valuable in assisting the managers in managing the projects.
* CPM & PERT – time oriented methods
* CPM – an activity oriented network
* PERT – event oriented
* CPM – Single time estimate – deterministic
* PERT – three time estimates for activities and uses probability theory to find the chance of reading the scheduled time.

Network Diagram Representation :

(*) Activity :



* Any individual operations which utilizes resources & has an end & a beginning is called activity.

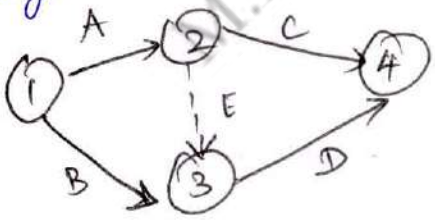
* Arrow - used to represent an activity head - indicates direction of progress in the project. 1 —A→ 2 , here 'A' is the activity.

(i) Predecessor activity : → completed immediately prior to the start of another activity.

(ii) Successor activity : → can't be started until one or more of other activities are completed but immediately succeed them.

(iii) Concurrent activity : → accomplished concurrently.

(iv) Dummy activity : → does not consume any kind of resource & time ; drawn to maintain logic in the network ; dotted line.



A , B → Preceding activity

C → dependent on activity A & B.

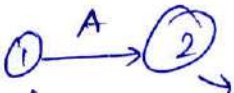
D → dependent on activity B

A & B → Concurrent activity, starting at same time.

E → dummy activity. & marked as dotted line.

Event :

* An event represents a point in time signifying the completion of some activities and the beginning of new ones.
* Represented by a circle in a network. (also called a node / connector)

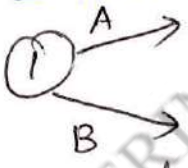


① & ② are called event.

↓ tail event → head event.

(i) merge event :- more than one activity comes & joins an event

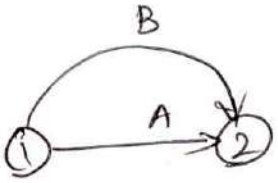
(ii) Burst event :- more than one activity leaves an event



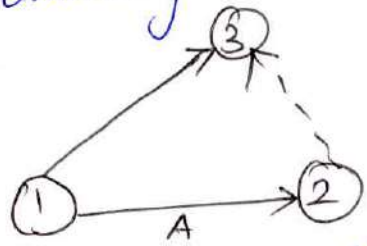
(iii) Merge & Burst event :- an event may be merge & burst event at the same time with respect to some activities.

Errors to be avoided in a Network Diagram :

* Two activities starting from a tail event must not have a same & event.
* To ensure this, dummy activity is introduced.

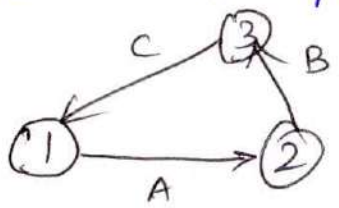


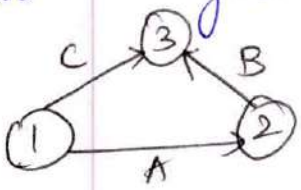
Incorrect method



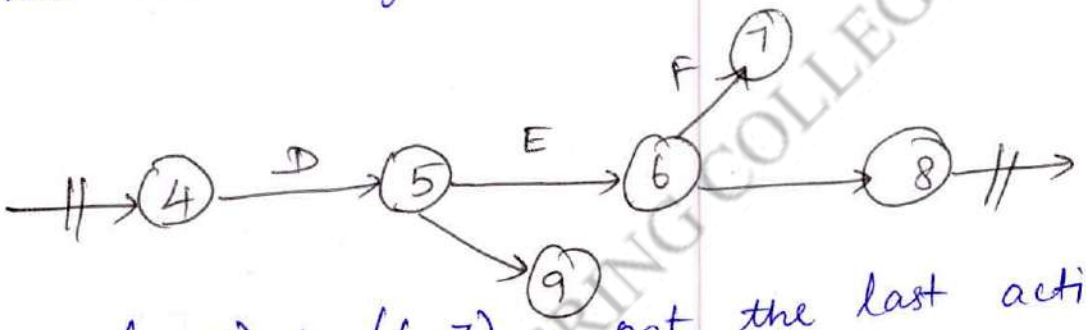
Correct method.

(ii) Looping error: - should not be formed in a network, repeatedly in a cyclic manner.





(iii) Dangling: - To disconnect an activity before the completion of all activities in a network diagram.



(5-9) & (6-7) → not the last activities in the network, so diag is wrong.

Suggested Questions / Assignments /Home works / any other

Text Books/ Reference Books

S.No	Title	Author	Publisher
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			

Any other suggested Materials

Lecture No. 6 **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	CPM & PERT

	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Rules for drawing network diagram:

* Each activity is represented by one & only one arrow in the network.
* No two activities can be identified by the same & events.
* Use straight arrows
* Use arrows from left to right
* Use dummies freely in rough draft
* only one start event & one point of emergence called end event.

Basic steps in PERT/CPM.

* Planning
* Scheduling
* Resource allocation
* Controlling

* Planning phase – splitting the total project into small projects → activities.

* Scheduling phase - Prepare a time chart showing the start and finish times for each activity as well as its relationship to other activities of the project.

* Allocation of resources – labour, finance, equipment & space.

* Final phase in project management is controlling.

Six steps common to both CPM & PERT:

1.) Define the project – several tasks, only a single start activity & single finish activity.

2.) Develop relationships among the activities.

3.) Draw the 'Network' connecting all the activities – unique event numbers.

4.) Assign time and/or cost estimates

5.) Compute the longest time path through the network. – This is called Critical path

6.) Use the Network to help plan, schedule, & monitor & control the project.

Critical Path Method (CPM) in Network Analysis :

* CPM - late 1950s - method to resolve the issues of increased costs due to inefficient scheduling.
* helps to break down complex projects into individual tasks and gain better understanding
* It revolves around most important tasks, in the project timeline, identifying task dependencies, & calculating task durations.

Basic scheduling Computations in CPM :

, (i,j) - Activity 'A' with tail event 'i' & head event 'j'.

E_i = Earliest occurrence time of event i.

L_j = Latest allowable occurence time of event j.

D_{ij} = Estimated completion time of activity (i,j)

$(E_s)_{ij}$ = Earliest starting time of activity (i,j)

$(E_f)_{ij}$ = Earliest finishing time of activity (i,j)

$(L_s)_{ij}$ = Latest starting time of activity (i,j)

$(L_f)_{ij}$ = Latest finishing time of activity (i,j).

(i) Determination of Earliest time (E_j) :

Foward Pass computation.

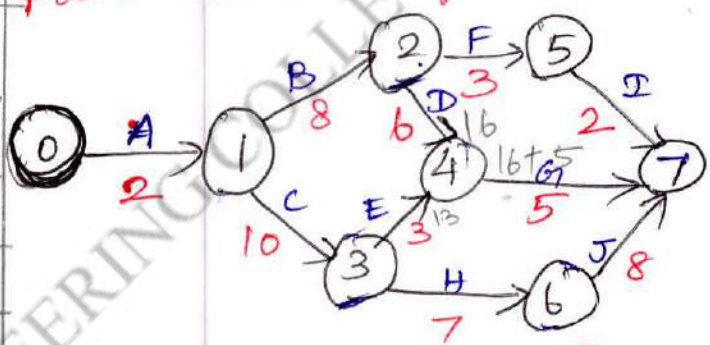
Step 1: * Starts node & move towards the end node.
* earliest occurence time (zero) for the initial project event.

(iv) Determination of Critical path :

* Critical event → event with zero slack times $E_i = L_j$.
* Critical activity → activities with zero float
* Critical path → sequence of critical activities in a network.
  ↳ longest path in a network.

Problem ①: Determine the early start & late start in respect of all node points & identify critical path for the full network.

Activity	duration (days)
0 – 1	2
1 – 2	8
1 – 3	10
2 – 4	6
3 – 4	3
2 – 5	3
3 – 6	7
5 – 7	2
6 – 7	8
4 – 7	5



(i) Earliest ~~starting~~ finishing time :

$E_{FT} = E_{ST} + t_{ij}$.

① – ② (A) $E_{FT} = 0$, ∴ @ 0

① – ② (B) $E_{FT} = 0 + 2 = 2$, @ 1

② – ⑤, $E_{FT} = 2 + 8 = 10$, @ 2

(F) $E_{FT} = 10 + 3$ @ 5

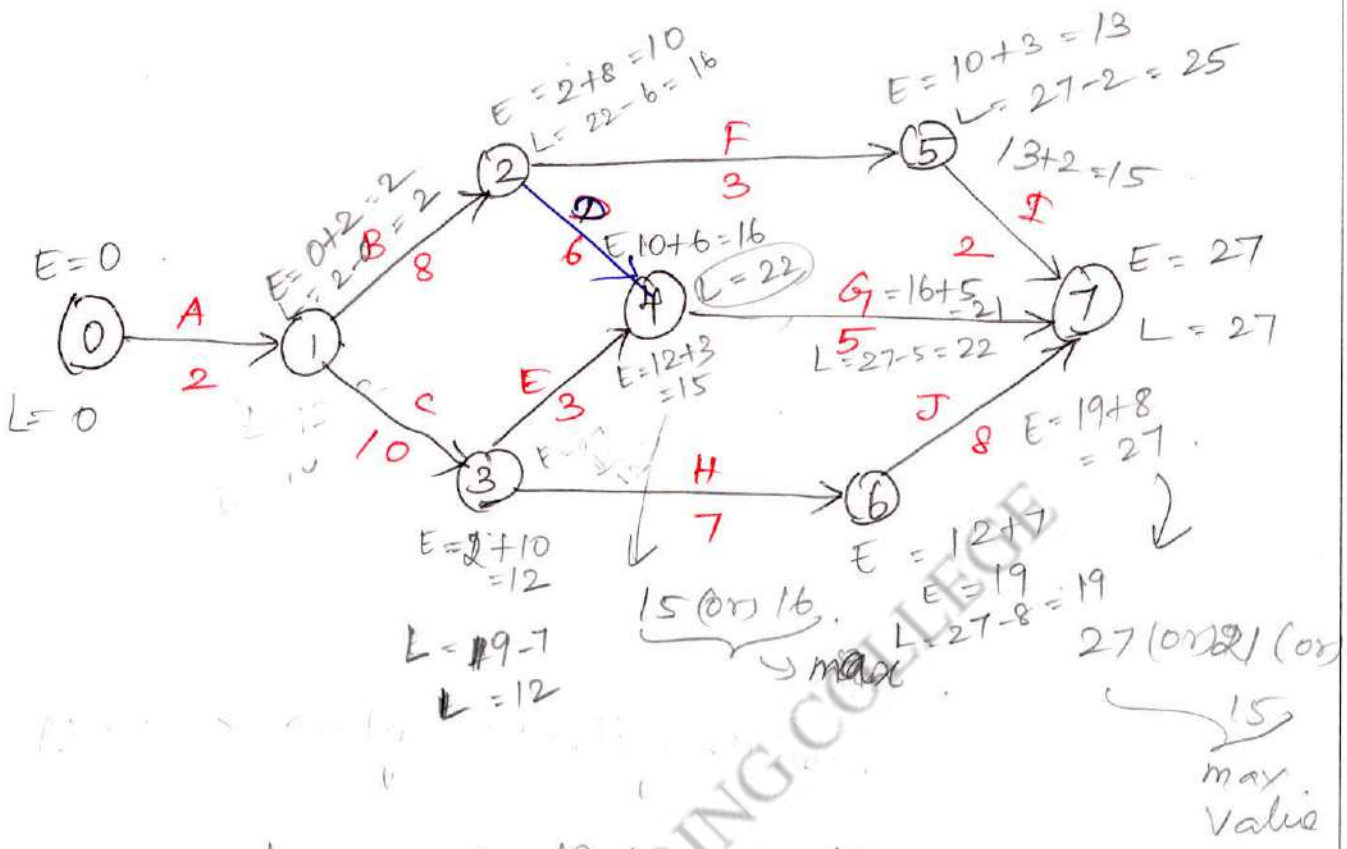
$E_{FT} = 13 + 2 = 15$ @ 7 ; E_{FT} (@3) $= 2 + 10 = 12$

(I) (C)

E_{FT} (E) $= 12 + 13$, E_{FT} (D) $= 10 + 6 = 16$.

$E_{FT} = 16 + 5 = 21$, E_{FT} (F) $= 13 + 5 = 15$

(G)



max. value → Earliest starting time

min. value → Latest finishing time.

① → ②,

Normal time, = 8.

Earliest start time = 0

Earliest starting time (Es) = 0 + 8 = 8 10.

Earliest Finish (Est)

Latest start time = 2 - 0 = 2.

(Ls)

Latest finish time = 2

(Lf)

Float time = Latest start time - Earliest start time

= 2 - 0 = 2.

Critical path : 0 → ① → ③ → ⑥ → ⑦ => 0.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 8 **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	Program Evaluation & Review Technique (PERT) in Network Analysis.

	Lecture Outcome (LO)	**Bloom's Level**
	At the end of this lecture, students will be able to	

Teaching Learning Material	**Student Activity**

Lecture Notes

PERT :

* Program Evaluation & Review Technique
* to create an initial schedule for a complex project.
* to estimate probabilities of time of various activities.

Optimistic Time (to) : - shortest possible time
everything goes well

Pessimistic Time (tp) - longest time
- everything goes wrong

Most likely time - estimate of the normal time (tm) the activity would take.

→ PERT scheduling is used instead of CPM scheduling if the duration of tasks is not straightforward.

→ It is a good option at the beginning of a project when actual duration of the project is not known.

Expected time :

* It is the average time an activity will take if it were to be repeated on large number of times & is based on the assumption that the activity time follows Beta distribution, this is given by,

$$t_e = (t_o + 4t_m + t_p)/6.$$

Variance : $\sigma^2 = [(t_p - t_o)/6]^2$

Difference between CPM & PERT :

* PERT is probabilistic in nature
* CPM is deterministic in nature

CPM	PERT
* deterministic in nature * most appropriately used in projects in which activity durations are known * useful for projects that are repetitive & standardized, like those involving construction activities. * strong emphasis on cost & time - cost relationships and trade - off. * activity oriented	* Probabilistic in nature * it acknowledges and considers the variability in completion times of activities & in turn the project. * Useful for projects, that are new, non - repetitive, research & development. * focuses on time element & attaches lesser significance to the cost * event oriented

Advantages of PERT & CPM :

* A CPM / PERT chart explicitly defines & makes visible dependencies b/w the elements

* Facilitates identification of critical path
* facilitates identification of early start, late start & slack for each activity
* They provides for potentially reduced project duration due to better understanding of dependencies leading to improved overlapping of activities & tasks where feasible

Disadvantages :

* lack of timeframe on most CPM/PERT charts makes it harder to show status although colours can help.
* no longer used to manage the project, when they become unwieldy.
* activities & individual dependency relationships will be complicated for big projects.

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Lecture No. 9 **UNIT V – CONSTRUCTION PLANNING**

Topic(s) to be covered	Problems on PERT Program Evaluation & Review Technique in Network Analysis.

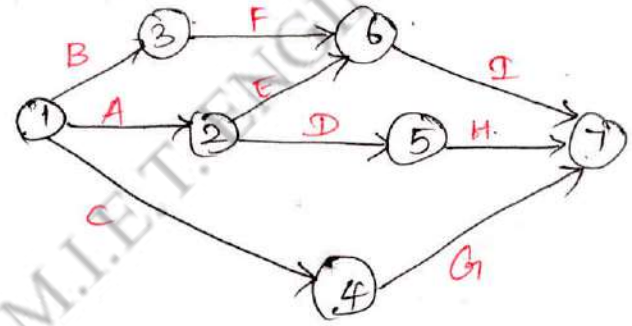
	Lecture Outcome (LO)	Bloom's Level
	At the end of this lecture, students will be able to	

Teaching Learning Material	Student Activity

Lecture Notes

Problem:

A project is represented by the network as shown below & has the foll. data.



Task	A	B	C	D	E	F	G	H	I
Least time	5	18	26	16	15	6	7	7	3
Greatest time	10	22	40	20	25	12	12	9	5
Most likely time	8	20	33	18	20	9	10	8	4

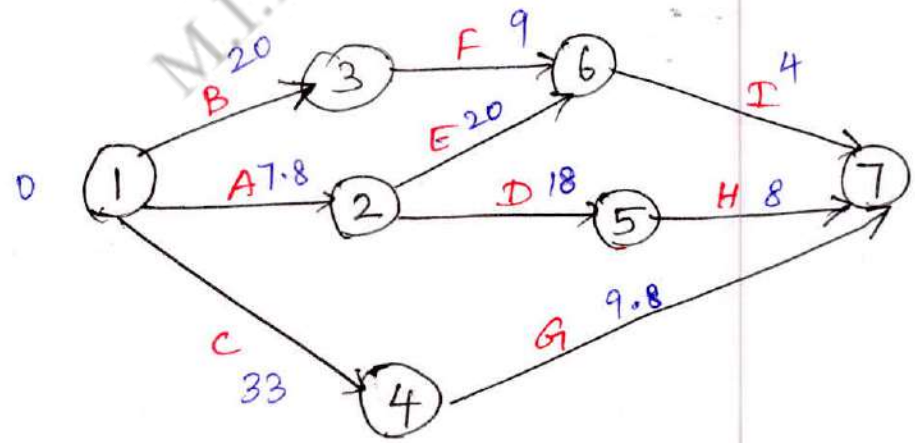
Determine the foll;

1.) Expected task time and their variance

2.) Earliest & latest time.

Solution:

Activity	Least time (t_o)	Greatest time (t_p)	Most likely time (t_m)	Expected time $(t_o+t_p+4t_m)/6$	$4t_m$	Variance $\sigma^2=\left[\frac{t_p-t_o}{6}\right]^2$
(1-2) A	5	10	15	60	~~12~~ 57.8	~~0.69~~ 0.69
(1-3) B	18	22	20	80	~~20~~	~~0.44~~
(1-4) C	26	40	33	132	33	5.43
(2-5) D	16	20	18	72	18	0.44
(2-6) E	15	25	20	80	20	2.78
(3-6) F	6	12	9	36	9	1.
(4-7) G	7	12	10	40	9.8	0.69
(5-7) H	7	9	8	32	8	0.11
(6-7) I	3	5	4	16	4	0.11



Earliest time can be calculated as follows;

$E_1 = 0$

$E_2 = 0 + 7.8 = 7.8$

$E_3 = 0 + 20 = 20$

$E_4 = 0 + 33 = 33$

$E_5 = 7.8 + 18 = 25.8$

$E_6 = \max[7.8 + 20, 20 + 9] = 29$

$E_7 = \max[33 + 9.8, 25.8 + 8, 29 + 4] = 42.8$

Latest time can be calculated as follows:

$L_7 = 42.8$

$L_6 = 42.8 - 4 = 38.8$

$L_5 = 42.8 - 8 = 34.3$

$L_4 = 42.8 - 9.8 = 33$

$L_3 = 38.8 - 9 = 29.8$

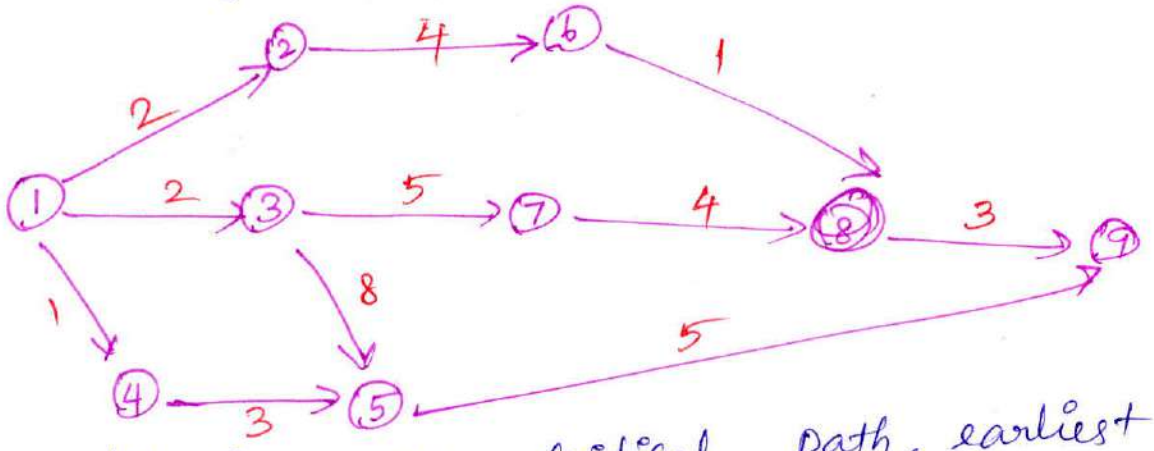
$L_2 = \min[34.8 - 18, 38.8 - 20] = 16.8$

$L_1 = \min[16.8 - 7.8, 29.8 - 20, 33 - 33] = 0$

Suggested Questions / Assignments /Home works / any other

	Text Books/ Reference Books		
S.No	**Title**	**Author**	**Publisher**
1.	Building Construction	Arora S.P and Bindra S.P	Dhanpat Rai and sons
2.			
3.			
Any other suggested Materials			

Find the critical path and calculate the slack time for the foll. network, float time,



soln: To determine the critical path, earliest start, finish & latest start & finish time for each activity of the project is to be computed:

To calculate Earliest time (T_E) for all activities,

$T_{E1} = 0$

$T_{E2} = 0+2 = 2$

$T_{E3} = 0+2 = 2$

$T_{E4} = 0+1 = 1$

$T_{E5} = \max(1+3, (2+8)) = 10$

$T_{E6} = 2+4 = 6$

$T_{E7} = 2+5 = 7$

$T_{E8} = \max$ of $(T_{E6}+t_6$ & $T_{E7}+t_7)$

$T_{E8} = \max(6+1=7, 7+4=11)$

$\therefore T_{E8} = 11$

$T_{E9} = \max(T_{E8}+t_8, T_{E5}+t_5, T_{E7}+t_7)$.

$T_{E9} = \max(11+3, 7+4+3, 10+5) = \max(14, 14, 15)$

$T_{E9} = 15$.

To calculate Latest time (T_L) for all activities,

$T_{L9} = T_{E9} = 15$

$T_4 = T_{E1} = 0$.

$T_{L8} = T_{E9} - t_{8,9} = 15-3 = 12$

$T_{L7} = T_{L8} - t_{7,8} = 12-4 = 8$

$T_{L6} = T_{L8} - t_{6,8} = 12 - 1 = 11$

$T_{L5} = T_{L9} - t_{5,9} = 15 - 5 = 10$

$T_{L4} = T_{L5} - t_{4,5} = 10 - 3 = 7$

$T_{L3} = T_{L7} - t_{3,7} = 8 - 5 = 3$ } min value

$T_{L3} = T_{L5} - t_{3,5} = 10 - 8 = 2$ }

$T_{L3} = 2$

$T_{L2} = T_{L6} - t_{2,6} = 11 - 4 = 7$

$T_{L1} = T_{L2} - t_{1,2} = 7 - 2 = 5$ } min value

$T_{L1} = T_{L3} - t_{1,3} = 2 - 2 = 0$ }

$T_{L1} = T_{L4} - t_{1,4} = 7 - 1 = 6$

$T_{L1} = 0$

Activity (i, j)	Normal time (Dij)	Earliest time		Latest time		Float time $(L_j - D_{ij}) - E_i^o$
		Start (E_i)	Finish ($E_i^o + D_{ij}^o$)	Start ($L_j - D_{ij}$)	Finish (L_j)	
(1,2)	2	0	2	5	7	5-0 = 5
(1,3)	2	0	2	0	2	0
(1,4)	1	0	1	6	7	6
(2,6)	4	2	6	7	11	5
(3,7)	5	2	7	3	8	1
(3,5)	8	2	10	2	10	0
(4,5)	3	1	4	7	10	6
(5,9)	5	10	15	10	15	0
(6,8)	1	6	7	11	12	5
(7,8)	4	7	11	8	12	1
(8,9)	3	11	14	12	15	1

Critical path = 1 → 3 → 5 → 9