BASIC OF CIVIL ENGINEERING (TCE 101)

UNIT- 3 (SYLLABUS)

CIVIL ENGINEERING MATERIALS

- Importance, properties, uses and quality tests of Timber
- Importance, properties, uses and quality tests of bricks
- Importance, properties, uses and quality tests of cement
- Importance, properties, uses and quality tests of aggregates
- Importance, properties, uses and quality tests of concrete

Timber

Wood is one of the most important engineering material. Wood has been classified in two categories:

(i) Fuel- Wood which is used as building material.

(ii) Timber-Wood which is used for engineering construction

Timber has many advantages due to which it is preferred over many other building materials.

It is easily available and easy to transport and handle

Has more thermal insulation, sound absorption and electrical resistance as compared to steel and concrete

Wood is a good absorber of shocks and so is suitable for construction work in hilly areas which are more prone to earthquakes

can be easily worked, repairs

Timber

CLASSIFICATION OF TREES:

Endogenous tress: Trees grow endwards, e.g. palm, bamboo, etc.

Exogenous trees: Trees grow outwards and are used for making structural elements. They are further subdivided as conifers and deciduous.

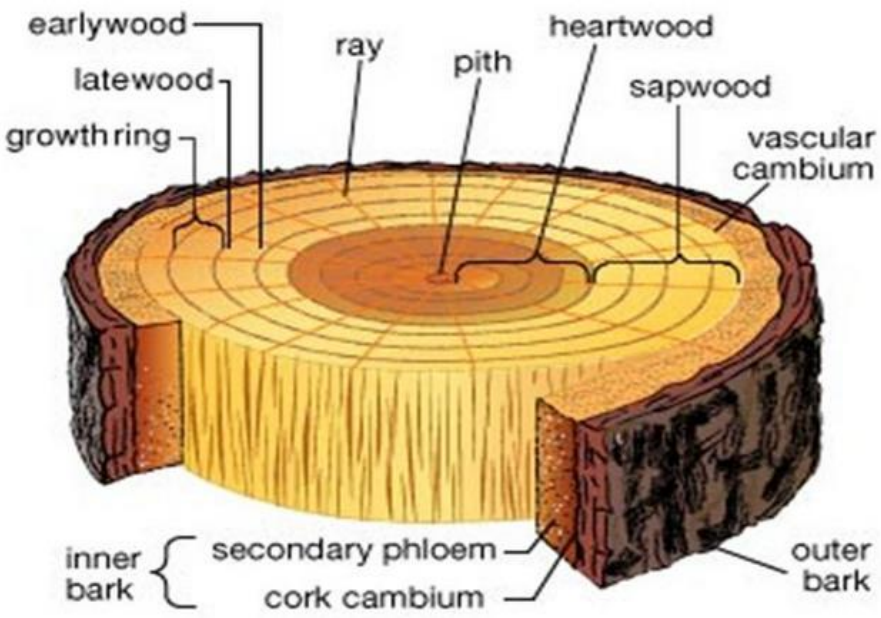
Conifers: are evergreen trees having pointed needle like leaves, light in colour, resinous and light weight e.g. deodar, chir, fir, kail, pine.

Decidous: trees have flat board leaves, they yield hard wood and are non-resinous, dark in colour and heavy weight. e.g. oak, teak, shishum, poplar and maple.

Timber

STRUCTURE OF TIMBERS:

- **Pith**: Innermost central portion of tree having dark brown color
- **Heart wood**: Around the pitch, a layer of dark color wood, which is dense and has compact structure.
- **Sap Wood**: Raw wood layer over heart wood, yellowish in color, can be easily decayed
- **Cambium Layer**: Below the bark, there is a thin film of soft wood
- **Medullary rays**: Thin fibers which extends from the pith outwards. The function of these fibers is to hold annual rings together
- **Bark**: Outermost cover of stem.



Timber

CHARACTERISTICS OF A GOOD TIMBER:

The principal characteristics of timber of are strength, durability and finished appearance.

- Narrow annual rings, closer the rings greater is the strength.
- Compact medullary rays.
- Dark color.
- Uniform texture.
- Sweet smell and a shining fresh cut surface.
- When struck sonorous sound is produced.
- Free from the defects in timber.
- Heavy weight.

Timber

SEASONING OF TIMBER:

Timber cut from freshly felled trees is too wet for normal use and is dimensionally unsuitable.

Seasoning is the process of reducing the moisture content (drying) of timber in order to prevent the timber from possible fermentation and making it suitable for use.

It is the process of removing the sap and reducing the moisture.

Advantages of seasoning of timbers:

Reduce the shrinkage and warping after placement in structure.

Increase strength, durability and workability.

Reduce its tendency to split and decay.

Make it suitable for painting.

Reduce its weight.

Bricks

Bricks are the most commonly used construction material. Bricks are prepared by molding clay in rectangular blocks of uniform size and then drying and burning these blocks. In order to get a good quality brick, the brick earth should contain the following constituents:

Clay

- When mixed with water forms plastic mass.
- Can be molded in any desired shape.
- Percentage of clay is 20-30% by weight

Sand

- Prevents shrinkage, warping and cracking of clay products
- Gives strength to brick
- Percentage of sand is 40-60 %

Lime

- Acts as a flux and forms calcium silicate when heated at high temperature.
- Prevents shrinkage and cracking
- But tends to expand and crack the brick when used in excess

Iron oxide

- When brick earth is heated it gives red color to bricks
- Helps in melting the sand at lower temp.
- Quantity is 8-10% (If excess bricks will turn blackish If less then color will be yellowish)

Bricks

The following are some harmful ingredients which may be present in brick earth

Pebbles or Grit

In the presence of pebbles, grit

- Clay will not mix thoroughly
- Brick after burning will not have uniform texture

Lime stone

Limestone after burning will form calcium oxide and when come in contact with water it will slake and brick will be damaged

Reh or Kallar

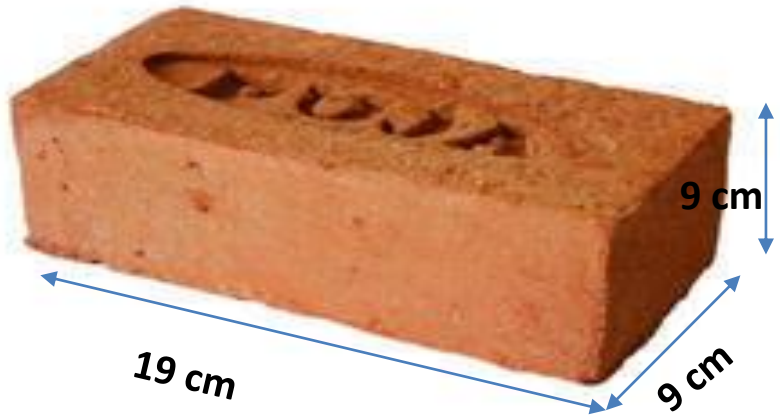
- Mixture of sodium sulphate, calcium chloride and sodium carbonate prevents brick from burning properly
- Causes plaster to peel off

Vegetable roots etc

- Causes difficulty in moulding of bricks
- Causes hollowness in bricks and bricks become more absorbent

Bricks

Size and Weight of Bricks:



- Indian Standard size of brick:
  19 cm X 9 cm X 9 cm
- Nominal size of brick:
  20 cm X 10 cm X 10 cm (with mortar thickness)
- Weight of metric brick:
  3 kg
- **500 bricks** will be required for **1 cubic metre** of masonary.

Bricks

Characteristics of good Bricks:

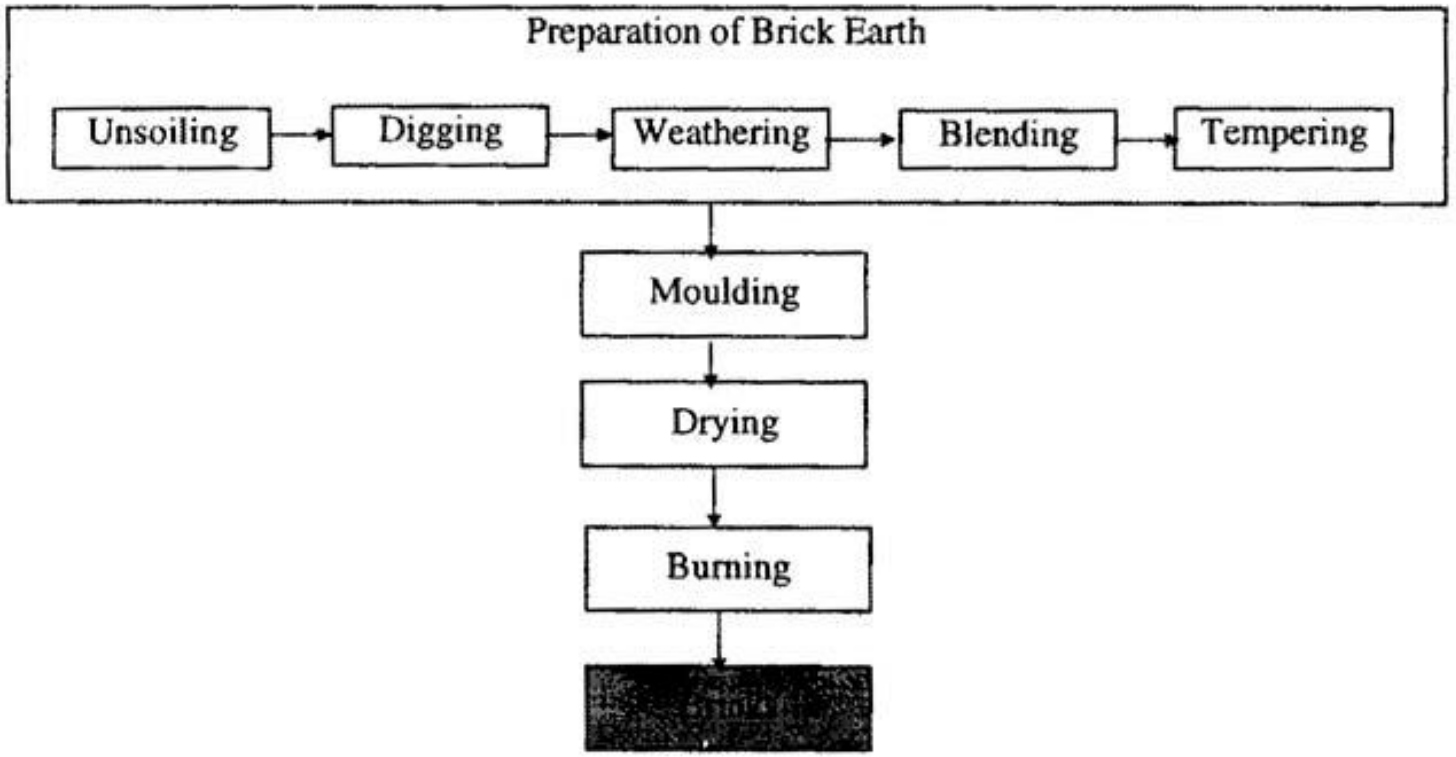
- Should have regular shape and size
- Should have smooth surfaces, sharp and straight edges
- Should have uniform brick red color
- Uniform texture
- Should not absorb more than 1/6 of its weight of water when immersed in water for sixteen hours
- Should have good strength. Crushing strength of ordinary bricks is 50-70 kg/cm^2

Bricks

Manufacturing of Bricks:

It involves four different operations:

- Preparation of earth
- Moulding
- Drying
- Burning



Bricks

Classifications of Bricks:

After burning of bricks, they can be classified into following four types:

(1) First class bricks
(2) Second Class bricks
(3) Third class bricks
(4) Overburnt bricks

(1) First class bricks

- These bricks are table moulded and of standard shape and they are burnt in kilns.
- The surface and edges of the bricks are sharp, square, smooth and straight.
- They comply with all the qualities of good bricks.
- These bricks are used for superior work of permanent nature.

(2) Second class bricks

- These bricks are ground moulded and they are burnt in kilns.
- The surface of these bricks is somewhat rough and shape is also slightly irregular.
- These bricks may have hair cracks and their edges may not be sharp and uniform.
- These bricks are commonly used at places where brick work is to be provided with a coat of plaster.

Bricks

Classifications of Bricks:

(3) Third class bricks

- These bricks are ground moulded and they are burnt in clamps.
- These bricks are not hard and they have rough surfaces with irregular and distorted edges.
- These bricks give dull sound when struck together.
- They are used for unimportant and temporary structures and at places where rainfall is not heavy.

(4) Overburnt bricks

- These are over burnt bricks with irregular shape and dark colour.
- These bricks are used as aggregate for concrete in foundations, floors, roads etc, because of the fact that the over burnt bricks have a compact structure and hence they are sometimes found to be stronger than even the first class bricks.

Bricks

Inspection and testing of Bricks:

(1) The bricks should be free from flaws and cracks.

(2) The length, height and width of bricks should be properly checked and verified.

(3) Hardness test: In this test a scratch is made on brick surface with a hard thing. If that doesn't left any impression on brick then that is good quality brick.

(4) Soundness test: In this test two bricks are held by both hands and struck with one another. If the bricks give clear metallic ringing sound and don't break then those are good quality bricks.

(5) Structure test: In this test a brick is broken or a broken brick is collected and closely observed. If there are any flows, cracks or holes present on that broken face then that isn't good quality brick.

Cement

Introduction

Cements in a general sense are adhesive and cohesive materials which are capable of bonding together particles of solid matter into a compact durable mass.

Chemical composition of raw materials:

Oxide	*Function*	*Composition (%)*
CaO	Controls strength and soundness. Its deficiency reduces strength and setting time	60–65
SiO_2	Gives strength. Excess of it causes slow setting.	17–25
Al_2O_3	Responsible for quick setting, if in excess, it lowers the strength.	3–8
Fe_2O_3	Gives colour and helps in fusion of different ingredients	0.5–6
MgO	Imparts colour and hardness. If in excess, it causes cracks in mortar and concrete and unsoundness	0.5–4
$Na_2O + K_2O$	These are residues, and if in excess cause efflorescence and cracking	0.5–1.3
TiO_2		0.1–0.4
P_2O_5		0.1–0.2
SO_3	Makes cement sound	1–2

Cement

Manufacturing of cement:

Calcareous and argillaceous raw materials are used in the manufacture of Portland cement.

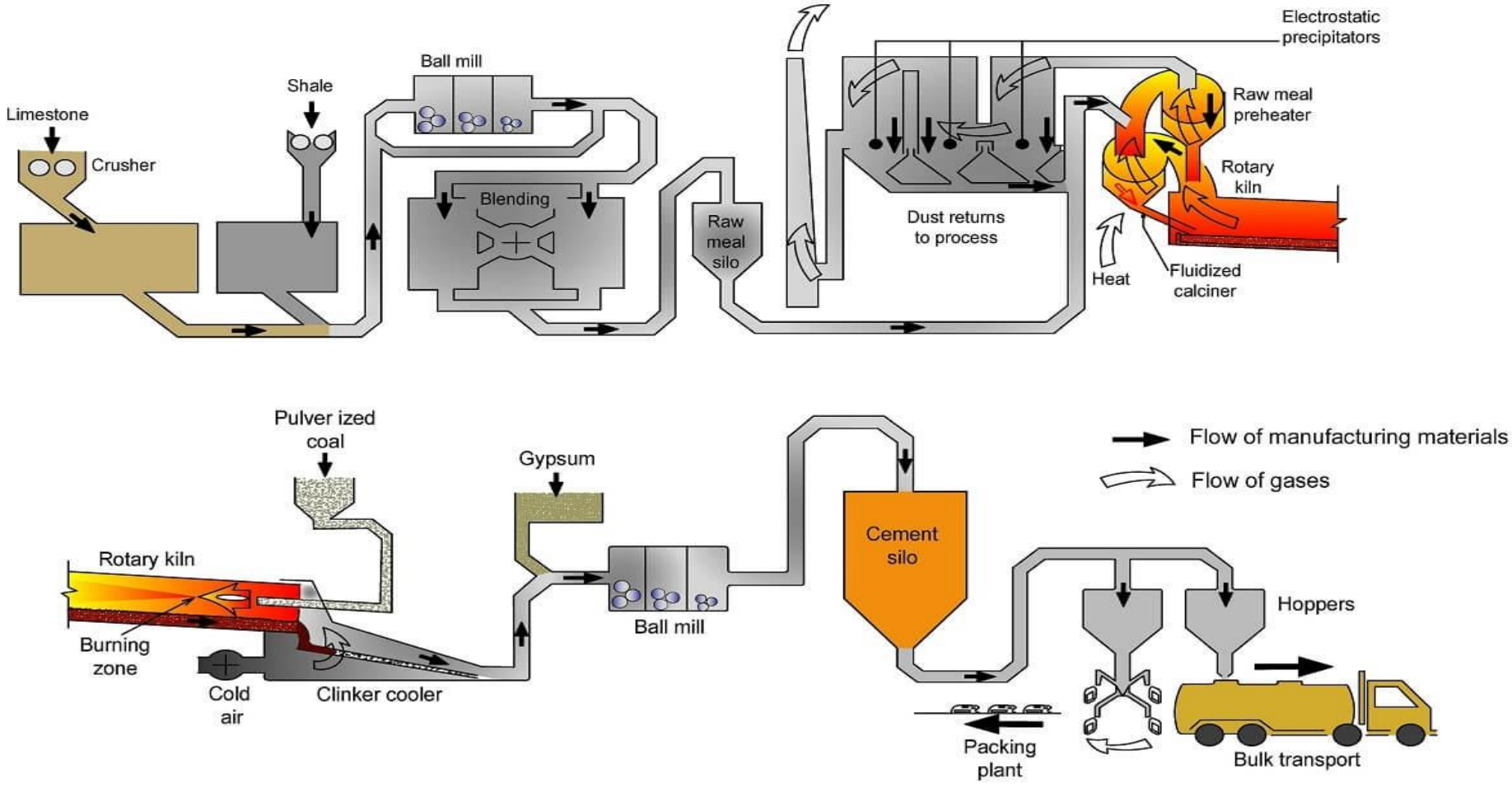
The calcareous materials used are cement rock, limestone, marl, chalk and marine shell. The argillaceous materials consist of silicates of alumina in the form of clay, shale, slate and blast furnace slag.

Cement can be manufactured either by DRY process or WET process.

DRY PROCESS

- The dry process is adopted when the raw materials are quite hard.
- The process is slow and the product is costly.
- Limestone and clay are ground to fine powder separately and are mixed.
- Water is added to make a thick paste. The cakes of this paste, which contain about 14 per cent of moisture, are dried and are charged into rotary kiln.
- The product obtained after calcination in rotary kiln is called *clinker. The clinker is obtained as a* result of fusion at a temperature of about 1400°- 1500°C.
- Because ferric oxide has lower melting point than the other oxides, it acts as a flux.
- Clinker is then cooled and ground in tube mills where 2-3% gypsum is added to slow down setting time.

Cement



Dry process for manufacturing of cement

Cement

Manufacturing of cement:

WET PROCESS

•The operations in the wet process of cement manufacture are mixing, burning and grinding.

•The crushed raw materials are fed into ball mill and a little water is added.

•On operating the ball mill, the steel balls in it pulverize the raw materials which form a slurry with water.

•This slurry is passed to silos (storage tanks), where the proportioning of the compounds is adjusted to ensure desired chemical composition.

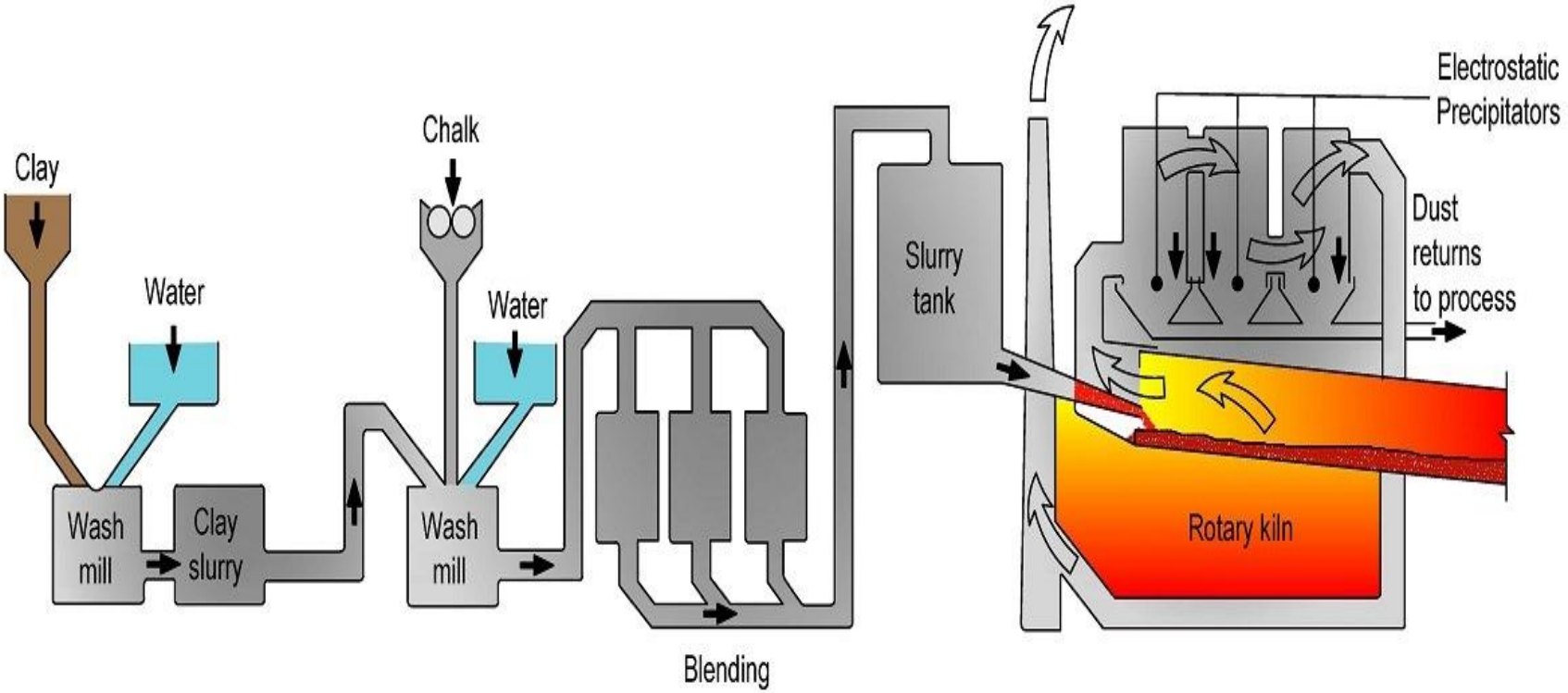
•The corrected slurry having about 40 per cent moisture content, is then fed into rotary kiln where it loses moisture and forms into lumps or nodules.

•These are finally burned at 1500-1600°C. The nodules change to clinker at this temperature.

•Clinker is cooled and then ground in tube mills. While grinding the clinker, about 3 per cent gypsum is added.

Cement

WET PROCESS



Cement

Types of cement:

(a) Ordinary portland cement (OPC):

OPC is prepared in three grades on the basis of compressive strength at 28 days as Grade 33, Grade 43 and Grade 53. The grade of cement indicates its mortar cube compressive strength in N/mm^2 at 28 days.

(b) Rapid hardening portland cement :

- It has high lime content. The basis of application of rapid hardening cement (RHC) is hardening properties and heat emission rather than setting rate.
- RHC attains same strength in one day which an ordinary cement may attain in 3 days. However, it is subjected to large shrinkage and water requirement for workability is more.
- The cost of rapid hardening cement is about 10 per cent more than the ordinary cement.
- suitable for repair of roads and bridges and when load is applied in a short period of time.

Cement

Types of cement:

(c) High alumina cement:

- The alumina content should not be less than 32%.
- It attains strength in 24 hours, high early strength, high heat of hydration and resistance to chemical attack.
- It should not be used in places where temperature exceeds 18°C.

(d) Portland slag cement :

- It is manufactured by intimately intergrinding a mixture of Portland cement clinker and granulated slag with addition of gypsum or calcium sulphate
- The slag constituent in the cement varies between 25 to 65 per cent.
- This cement can be used in all places where OPC is used. However, because of its low heat of hydration it can also be used for mass concreting, e.g., dams, foundations, etc.

(e) Portland puzzolona cement:

- It is manufactured by grinding Portland cement clinker and puzzolana (usually fly ash 10-25% by mass of PPC).
- Puzzolana (burnt clay, shale, or fly ash) has no cementing value itself but has the property of combining with lime to produce a stable lime-puzzolana compound.

Cement

Field tests of cement:

There are four field tests may be carried out to as certain roughly the quality of cement. There are four types of field tests to access the colour, physical property, and strength of the cement.

1) COLOUR

- The colour of cement should be uniform.
- It should be typical cement colour i.e. grey colour with a light greenish shade.

2) PHYSICAL PROPERTIES

- Cement should feel smooth when touched between fingers.
- If hand is inserted in a bag or heap of cement, it should feel cool.

3) PRESENCE OF MOISTURE

- Cement should be free from lumps.
- A handful of cement is thrown on a bucket filled with clean water. If it sinks immediately shows the moisture already present in cement

4) STRENGTH

- A thick paste of cement with water is made on a piece of thick glass and it is kept under water for 24 hours. It should set and not crack.

Aggregates

INTRODUCTION:

- Aggregates are the materials basically used as filler with binding material in the production of mortar and concrete.
- They are derived from igneous, sedimentary and metamorphic rocks or manufactured from blast furnace slag, etc.
- They occupy 70-80 per cent of the volume and have considerable influence on the properties of the concrete.
- The coarse aggregate form the main matrix of concrete and the fine aggregate form the filler matrix between the coarse aggregate.

Aggregates

CLASSIFICATION OF AGGREGATES:

AGGREGATE	AGGREGATE COMPONENT	PARTICLE SIZE RANGE AND DESCRIPTION
Coarse aggregates (80 mm to 4.75 mm)	Gravel	Coarse: 80 mm to 20 mm sieve
		Fine: 20 mm to 4.75 mm sieve
Fine aggregates	Sand	Coarse: 4.75 mm to 2 mm sieve
		Medium: 2 mm to 425 micron
		Fine: 425 micron to 75 micron
	Silt	Particles passing through 75 micron sieve and retaining on 2 microns sieve
	Clay/ Organic matter	Particles smaller than 2 micron

- *If particle size is greater than 80 mm and upto 30 cm, they are termed as **COBBLE.***
- *If particle size is more than 30 cm, then **BOULDERS.***

Aggregates

LIST OF IS CODES RELATED TO TESTING OF AGGREGATES:

TESTS FOR AGGREGATES WITH IS CODES		
Property of aggregate	**Type of test**	**Test method**
Crushing strength	Crushing test	IS : 2386 (part 4)
Hardness	Los Angeles abrasion test	IS : 2386 (Part 5)
Toughness	Aggregate impact test	IS : 2386 (Part 4)
Durability	Soundness test	IS : 2386 (Part 5)
Shape factors	Shape test	IS : 2386 (Part 1)
Adhesion to bitumen	Stripping value of aggregate	IS : 6241-1971

Admixtures

Admixtures are artificial or natural materials added to the concrete besides cement, water and aggregate to improve certain property of concrete during casting or setting or service stage.

Purpose of using admixtures

- To improve workability of fresh concrete
- To improve durability by entrainment of air
- To reduce the water required
- To accelerate setting & hardening & thus to produce high early strength
- To aid curing
- To impart water repellent / water proofing property
- To offset / reduce shrinkage during setting & hardening
- To cause expansion of concrete and automatic prestressing of steel
- To aerate mortar / concrete to produce a light-weight product

Types of admixtures

Chemical admixtures - Accelerators, Retarders, Water-reducing agents, Super plasticizers, Air entraining agents etc.

Mineral admixtures - Fly-ash Blast-furnace slag, Silica fume and Rice husk Ash etc

Mortar

MORTAR:

Building mortars are mixtures used for the jointing of bricks, stones, blocks, etc. Mortar may be defined as a paste (capable of setting and hardening) obtained by adding water to a mixture of fine aggregates such as sand and binding material, e.g., clay, gypsum, lime or cement or their combinations.

CLASSIFICATION OF MORTAR:

On the basis of binding material

Cement mortar are prepared from Portland cement or its varieties, sand and water.

Lime Mortar are mixture of air hardening lime or hydraulic lime, sand and water.

Gypsum Mortar are prepared from gypsums or anhydride binding materials.

Mud Mortar are prepared from clay nodules and are used in construction of houses for poor and temporary construction works.

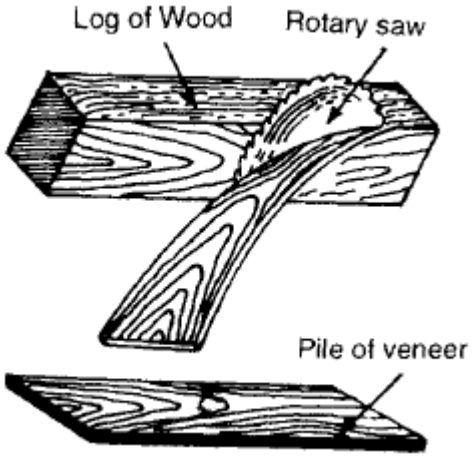
Composite mortar may be surkhi-mortar (surkhi, lime and water), lime-surkhi-sand mortar, cement-lime mortar and cement-clay mortar.

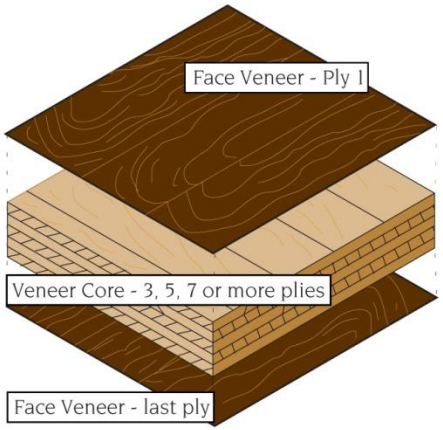
Plywood

PLYWOODS:

Plywood are thin boards made by gluing together thin sheets of veneers, under pressure. Veneers are thin layers of soft wood 2mm to 6mm in thickness, sliced in continuous thin sheets.

- Two sheets of veneers of high quality are used on face and back of plywood are called faces.
- Intermediate veneers of inferior quality are called cores.
- Plywood is lighter in weight, better in appearance, can bent in desired shapes





Glass

Glass is an amorphous substance having homogeneous texture. It is a hard, brittle, transparent or translucent material. It is the most common material glazed into frames for doors, windows and curtain walls.

Constituents in glass:

The raw materials used in manufacturing glass are sand, lime and soda or potash which are fused over 1000° C. Oxides of iron, lead and borax are added to modify hardness, brilliance and colour.

Manufacturing of glass:

Melting: The raw materials — lime, soda and sand — separately cleaned, ground, sieved in definite proportion and mixed with water are fused in a furnace. The charge in the first stage melts, forming a bubbly, sticky mass, and as the temperature is raised (1100° C–1200° C) it turns to a more watery liquid and the bubbles rise to the surface. Heating is continued till the molten mass is free from bubbles and glass balls. As the glass cools (800° C), it is ready to be drawn or floated to its desired thickness and size.

Forming and shaping: Glass articles are allowed to cool under room temperature by passing through different chambers with descending temperature. If cooled rapidly, the glass being bad conductor of heat under the process of annealing. After annealing the glass articles are cleaned, ground, polished, cut and sand blasted.

Plastics

PLASTICS:

Plastics are made from resin with or without fillers, plasticisers and pigments.

Plastics are replacing glass, ceramics and other building materials due to the low temperature range in which they can be brought to the plastic state and the consequent ease of forming and fabrication and also for their low cost and easy availability.

CLASSIFICATIONS OF PLASTICS:

1) **Thermoplastics**: The thermoplastic variety softens on heating and hardens on cooling, *i.e., their hardness is* a temporary property subjected to change with rise or fall of temperature and can be brought again to plastic stage on heating. These are formed by addition polymerisation and have long chain molecular structure. They can be remoulded, for use, as many times as required.
2) **Thermosetting plastics:** Thermosetting plastic cannot be reused. They require great pressure and momentary heat during moulding and finally get hardened on cooling. The chemical reaction in this process cannot be reversed. Once solidified they cannot be softened. Compared to thermoplastics, they are hard, strong and more brittle.

Concrete

DEFINITION:

Concrete is the composite material that is created by mixing binding material (cement) along with the aggregate (sand, gravel), water, admixtures, etc in specific proportions.

COMPOSITION OF CONCRETE MIX:

- **Binding materials (cement):**When water is mixed with the cement, a paste is created that coats the aggregates within the mix. The paste hardens, binds the aggregates, and forms a stone-like substance.
- **Coarse aggregate (stone chips)**: Acts as filler material and provide volume to concrete.
- **Fine aggregate (sand):** Acts as filler material in concrete and make it more compact. Reduces the shrinkage of concrete.
- **Water:** Helps in hydration of cement and and uniform mixing of ingredients
- **Admixture (e.g. Pozzolana):** enhances properties of concrete.

Concrete

DESIRED PROPERTIES OF CONCRETE:

- The concrete mix is workable. It can be placed and consolidated properly.
- Desired qualities of the hardened concrete are resistance to freezing and thawing and deicing chemicals, water tightness (low permeability) , wear resistance, and strength
- Economy. Since the quality depends mainly on the water to cement ratio, the water requirement should be minimized to reduce the cement requirement (and thus reduce the cost).

TYPES OF CONCRETE:

- Plain/ordinary concrete
- Light Weight concrete
- High density concrete
- Reinforced Concrete
- Precast concrete
- Self compacting concrete