ELEMENTS OF ENGINEERING I (ENGG 111)

Civil portion

BUILDING MATERIALS COMPONENETS AND STRUCTURE

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Date: May 17, 2023

Element of Engineering I (ENGG 111)
Civil portion

Total weightage: 20 out of 100 marks

- Internal evaluation: 5
- External evaluation: 15

Internal evaluation

- Assignment
- Internal exam
- Attendance

BUILDING MATERIALS

Lecture 1

INFRASTURCTURE OF DEVELOPMENT



CIVIL ENGINEERING STRUCTURES







stone


gravel


Coarse gravel


brick


sand


sand


cement


Metals/iron

CIVIL ENGINEERING MATERIALS

Materials used in construction or the materials used to produce other materials used in civil constructions such as Buildings, Bridges, Dams, Canals, Roads etc. are known as Civil Engineering Materials.

TYPE OF BUILDING MATERIALS

Figure: stone

A. Depending upon existence:

i) Natural Construction Materials

- Formed by natural process
- Sand, Stone, Mud, Gravels etc.

ii) Man made Construction Materials

- Formed after manual processing during manufacture
- Steel, Bricks, Glasses etc.

Figure: Bricks

B. Depending upon usage:

i) Structural Materials - Bricks, Stones, Steel, Sand etc.

ii) Aesthetic Materials - Paints, Tile, Marble stone etc.

iii) Special Purpose Materials - Sanitary Fittings, Pipes etc.

C. Depending on Metallurgy:

- The branch of science and technology concerned with **the properties of metals and their production and purification.**

Types

a. Metals: Any of a class of substances characterized by high electrical and thermal conductivity as well as by malleability, ductility - Steel, Copper, Aluminum etc.

b. Non-Metals – **any substance that lacks property of metals**: Wood, Glasses, Plastic etc.

D. Depending on Composition:

i) Ceramics

- is a **material that is neither metallic nor organic**
- Baking natural clay and minerals admixtures at high temperature
- It may be crystalline, glassy or both crystalline and glassy.
- Clay, bricks, tiles, glass, and cement are probably the best-known examples

ii) Polymers

A polymer is a large molecule or a macromolecule which essentially is a combination of many subunits e.g. Green House Plastics etc

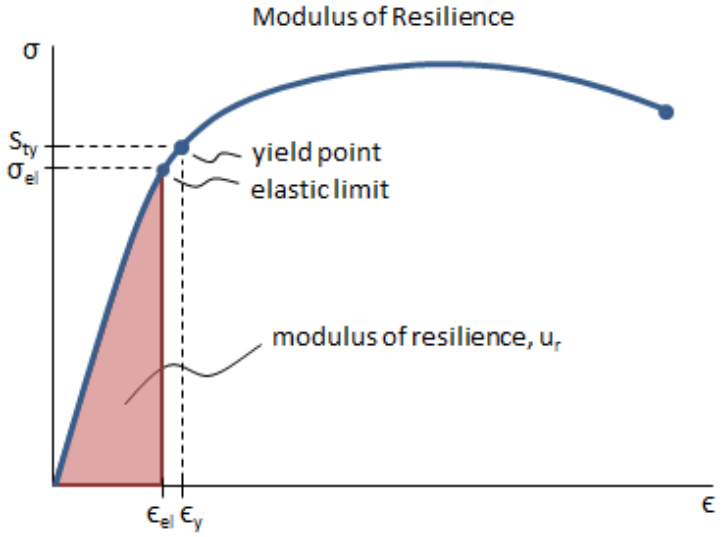
PROPERTIES OF CONSTRUCTION MATERIALS

A. Physical Properties

- Dimension (Shape and Size)
- Water Absorption Capacity
  - ✓ Water absorbed/Dry Wt. of Material
- Specific Gravity
  - ✓ratio of the density of a substance to that of a standard substance
- Soundness
  - ✓resist against heat and moisture
- Frost Resistance
  - ✓resist against repeated action of freezing and thawing
- Porosity
  - ✓ Vol. of Voids/Total Volume
- Permeability
  - ✓ Property to permit flow of water through

B. Mechanical Properties

- Strength: the capacity to withstand great force or pressure
  - ❖ Compression,
  - ❖Tension,
  - ❖Bending
- Resilience
  - ❖ Energy stored in material when strained within elastic limit.
  - ❖ The area under the stress–strain curve till the point of elastic limit.
- Hardness
  - ❖ Resist penetration of surface
- Toughness
  - ❖The ability of a material to absorb the energy and gets plastically deformed without fracturing or broken.
- Ductility
  - ❖ Being permanently extended to wire
- Malleability
  - ❖ Permanently extended to sheet



- **Elasticity: opposite to plastic deformation**
- **Creep**
  - ✓Creep is the property of a material which indicates the tendency of material to move slowly and deform permanently under the influence of external mechanical stress.
  - ✓It results due to long time exposure to large external mechanical stress
- **Fatigue**
  - ✓Fatigue is the weakening of material caused by the repeated loading of the material.
  - ✓When a material is subjected to cyclic loading, and loading greater than certain threshold value but much below the strength of material **microscopic cracks** begin to form at grain boundaries and interfaces
- **Tenacity:**
  - ✓refers to a mineral's toughness or resistance to breaking or being deformed

DETAILS OF VARIOUS CONSTRUCTION MATERIALS

A. BRICKS

Bricks are obtained by molding Clay to suitable shape size, dried and burnt in Kilns or clamps.

Composition of Bricks:

1. Silica (50-60 %)
2. Alumina(20-30%)
3. Lime(2-5 %)
4. Iron oxide(<7%)
5. Magnesia(<1%)
6. Alkalis(<10%)

Figure: Bricks

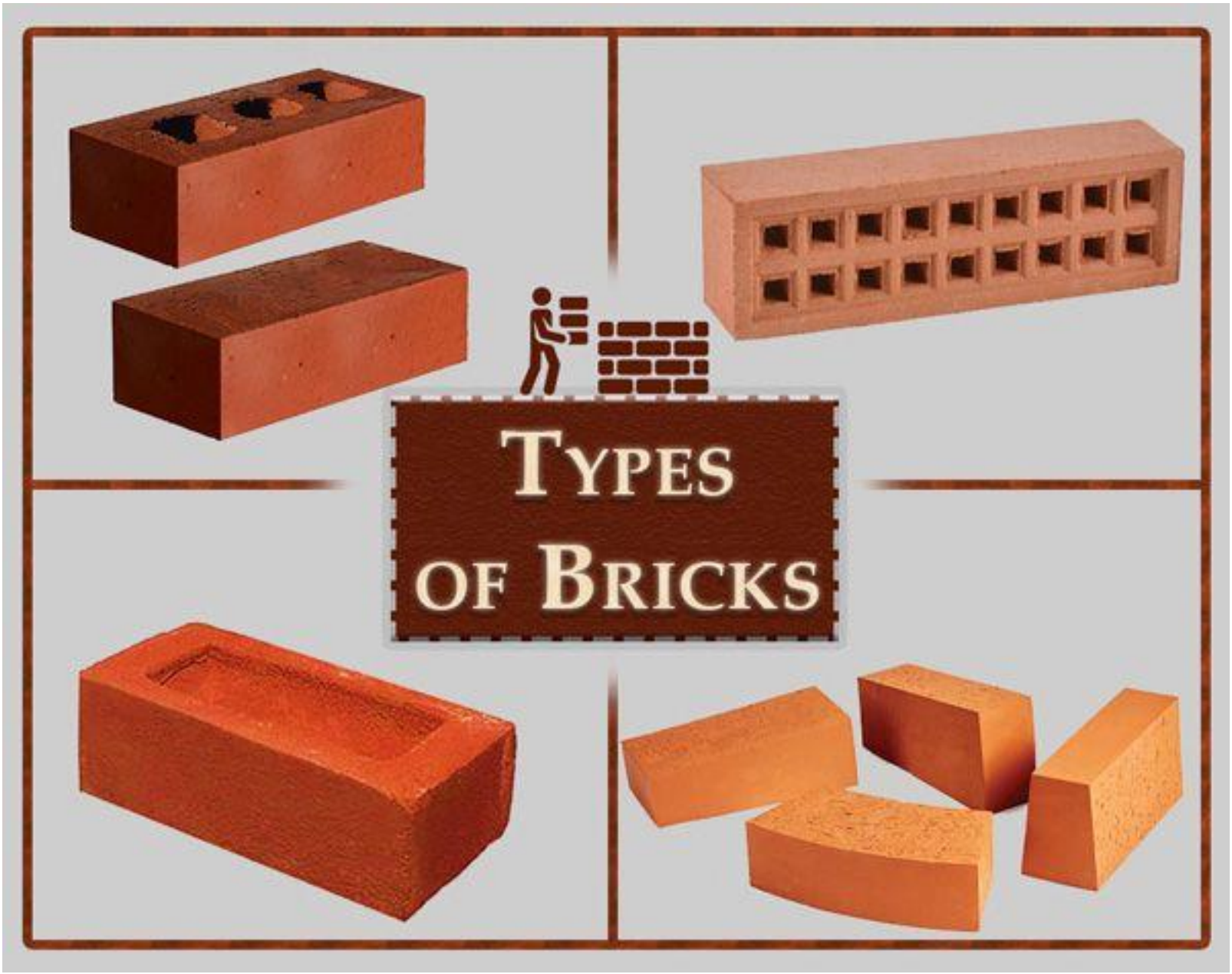
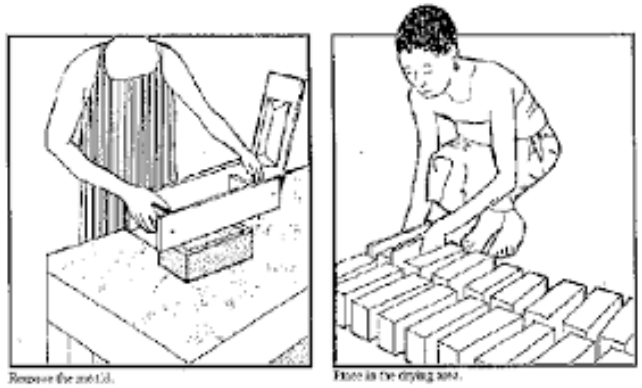


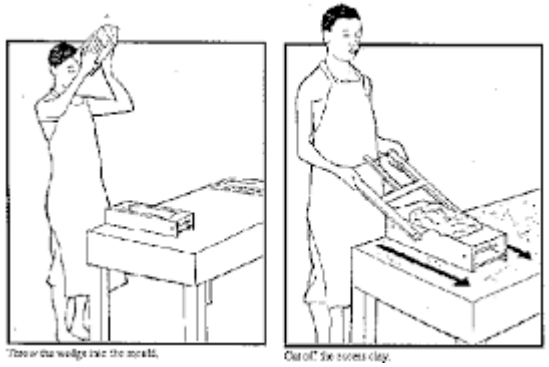
Figure: Types of bricks

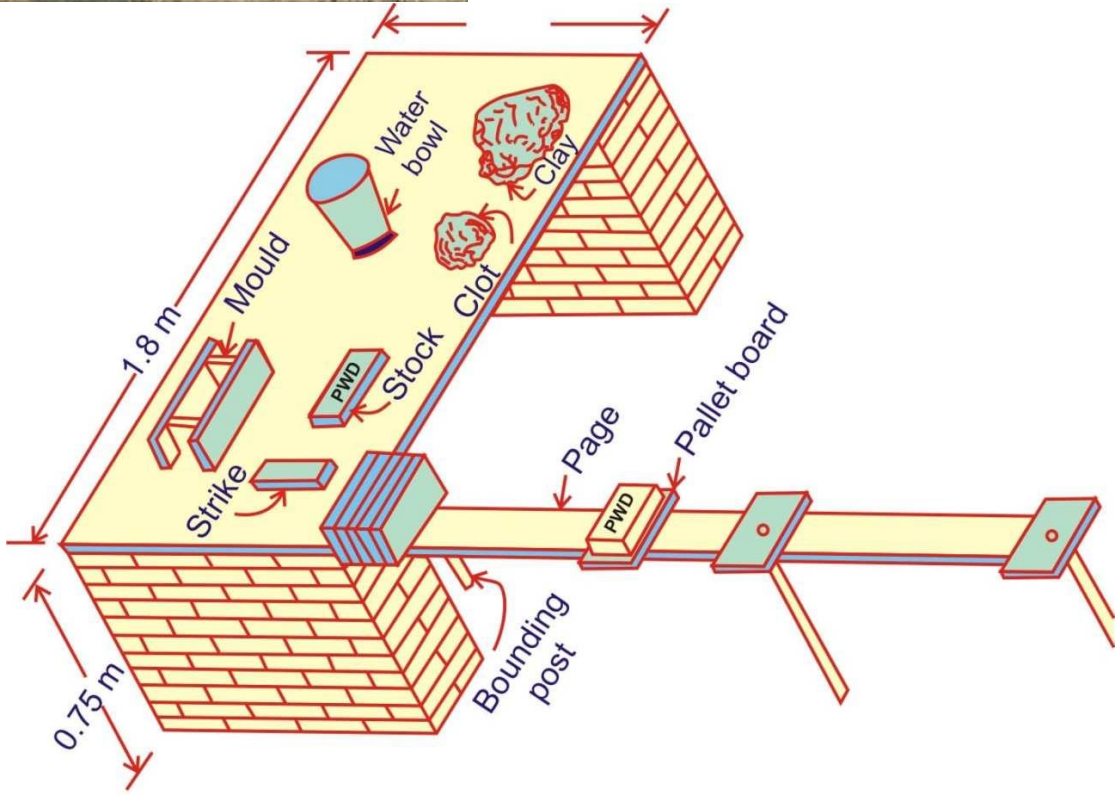
DIFFERENT BRICKS ON BASIS OF SURFACE

Figure: Types of bricks having different surface

MOULDING OF BRICKS





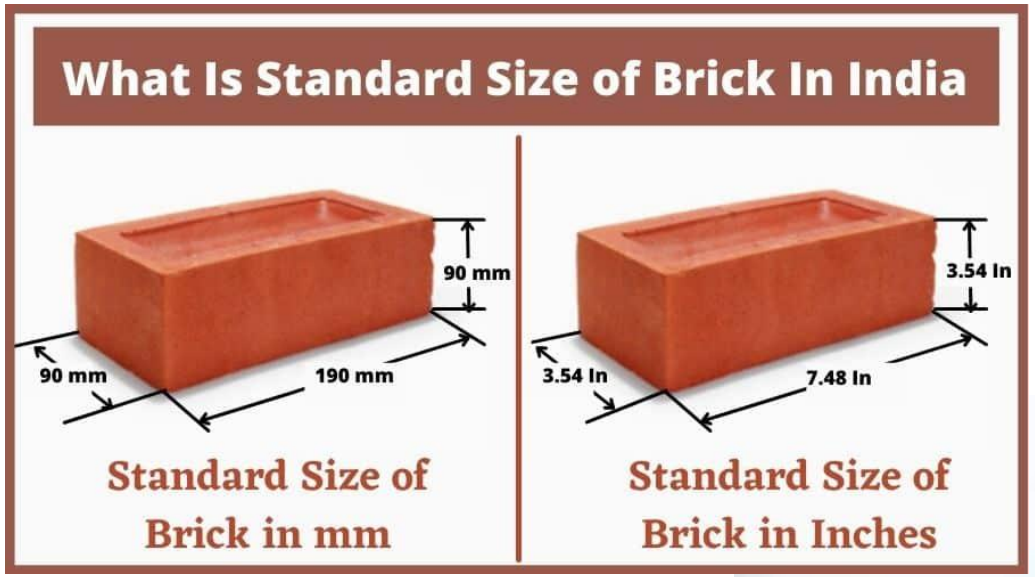


1. **Silica/sand (50-60%):** enables to **retain shape, imparts durability, prevents shrinkage and wrapping, excess silica makes brittle and weak.**
2. **Alumina/clay (20-30%):** it **absorbs the water and renders clay plastic, excess of it causes cracks in brick on burning**
3. **Lime (<10%)** : it **reduces shrinkage of brick, and acts as flux to melt silica, excess causes brick to melt and loss shape**
4. **Alkalis <10%** : act as flux causing the **brick to melt and quick setting, excess alkalis causes efflorescence, <7% : gives color to the brick, excess makes color dark and blue**
5. **Magnesia 1%** : causes clay **to soften at slower rate and reduces wrapping, excess of it makes yellow color**.

Types:

Based on physical and mechanical properties:

- 1st Class Brick
- 2nd Class Brick
- 3rd Class Brick
- 4th Class Brick



1st Class Bricks

- Table molded and of standard Size

  IS:190*90*90

  NS: 230*110*55 or 224*108*57 mm

- Water Absorption:12-15% of dry weight when immersed in cold water for 24 hrs.
- Compressive Strength >=10 MPa
- Burnt in Brick Kilns

2nd Class Bricks

- Ground molded: The process of moulding bricks on the ground manually by labour
- Water Absorption:16-20% of dry weight when immersed in cold water for 24 hrs.
- Compressive Strength should not be less than 7 MPa and greater than 10 MPa
- Surface somewhat rough, edges are not Sharp and Uniform
- Burnt in Brick Kilns

3rd Class Bricks

THIRD CLASS BRICKS

- Ground molded
- Water Absorption: Nearly 25% of dry weight when immersed in cold water for 24 hrs.
- Surface somewhat rough, edges are not Sharp and Uniformity is distorted
- Burnt in Clamps
- Under burnt
- Produces dull sound when stuck together
- Compressive Strength:<7 Mpa

4th Class Bricks


FOURTH CLASS BRICKS

- Over burnt
- Highly distorted
- Dark color
- Compressive Strength: very high
- Used as aggregate for concrete in foundation, floor and roads

Properties of Good Bricks:

a) Color: Uniform and bright
b) Shape: Plane shape, edges sharp, right angled corners
c) Size: Standard Size as specified earlier
d) Texture: No fissures, cavities on its body
e) Hardness: Finger scratching produce no impression
f) Strength: Should Not be less than 3.5 MPa; And when a brick sample is dropped from 0.9-1 m height, it should not break.
g) Water Absorption: Should not be more than 20 % of dry wt.
h) Efflorescence: Should not show white patches when soaked in water for 24 hrs.
i) Thermal Conductivity(TC) : low
j) Sound Insulation
k) Fire Resistive

USAGE OF BRICKS

- Walls
- Pitching in road (Cycle tracks)
- Soling purpose
- Lining in Furnaces and Chimney

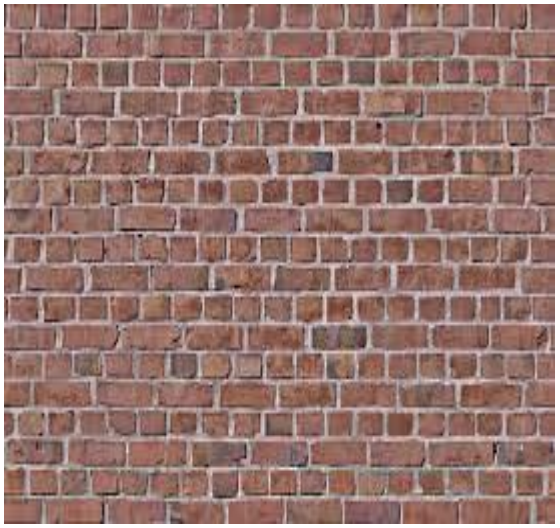


Figure: usages of bricks for different purposes

STONES






Figure: Stones

B. STONES

- Naturally available building material
- Derived from rocks
- Does not have definite shape or chemical composition.

Types:

Geological Classification

l. Igneous Rock

Rocks formed by cooling and solidifying of rock masses from their molten state Eg: Granite Basalt

2. Sedimentary Rock

These are rock which are formed by graduation deposition of disintegrate rocks such as sand, clay . Eg: Limestone, Sandstone, Mudstone

3. Metamorphic Rock

Igneous and Sedimentary rocks undergo changes under extreme pressure and heat to produce metamorphic rock. Eg.Schist, Marble, Quarzite, Slate

Physical Classification

- Stratified rock: Are layered in structure. E.g.: Limestone, sandstone
- Unstratified Rock: Not stratified E.g.: Granite, Basalt
- Foliated Rock: Tendency to split along definite direction only e.g.: Slaty, phyllite,

Chemical Classification: on the basis of chemical contents

- Silicious Rock: main content silica eg Granite, sandstone
- Argillaceous Rock: main content clay or alumina E.g.: Slate, laterite
- Calcareous Rock: main content $CaCO_3$ e.g.: Limestone, marble

Requirement of Good Building Stone

a) **Strength**: resist load imposed on it [tension and compression]
b) **Specific gravity**: 2.4 to 2.8
c) **Stiffness**: resist against deformation
d) **Hardness**: resist against wear and tear
e) **Durability**: resist effect of rain, wind, heat
f) **Toughness**: sustain stress against fracture
g) **Appearance**: if used in face works then appearance and color matters
h) **Cost**: easiness in quarry

C. SAND

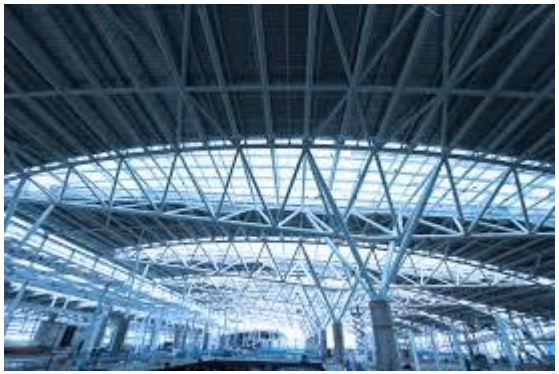
- Sand is naturally occurring granular material composed of **finely divided rock mineral silica.**
- Size: 0.075 mm to 4.75 mm IS sieve

Properties Of Good Sand

1. Clean and coarse
2. Free from organic matters
3. Chemically inert
4. Contain angular sharp coarse grain
5. Well graded

D. METALS

Structural Framework for larger buildings



Features of Structural Steel

1. High Tensile Strength
2. Ductility
3. Malleability
4. Toughness
5. Ease in fastening: Weldability
6. Durability

Classification of Metals

1. Ferrous Metals

Iron is main constituent

Iron ore, Pig iron (basic material from which wrought iron & steel are manufactured)

- Cast iron (1.7 to 4.5 % Carbon Content)
- Wrought Iron (0.05 to 0.15 % C Content)
- Steel (0.25 to 1.5 % C content)

Cast Iron

1. Compressive Strength: 700 MPa
2. Brittle: hard but liable to break easily
3. Specific Gravity:7.5
4. Coarse Crystalline Fibrous
5. Does not rust easily
6. Low melting point nearly 1200 degree

Wrought Iron

1. Compressive Strength: 200 MPa
2. Brittle
3. Specific Gravity:7.7
4. Coarse Crystalline Fibrous
5. Rust easily
6. Melting point 1500 degree celsius

Steel:

- an alloy of iron and carbon
- Steel can be made from different methods from pig iron

1. Mild Steel

- ✓ 0.25 % C, 0.055 % S ,0.55 % P
- ✓ Malleable and ductile
- ✓ Magnetized permanently
- ✓ Specific gravity 7.8
- ✓ Welded easily
- ✓ Strong in tension and compression
- ✓ Use: Rolled I ,H ,T ,C section

2. High Tension steel

- ➢ 0.80 % C,0.60 % Manganese
- ➢ Strength High
- ➢ Strong in tension
- ➢ ‘Use: Prestress Concrete

3. High Carbon steel

0.7 to 1.5 %C

- ✓ Brittle: hard but easily broken
- ✓ Magnetized permanently
- ✓ Welding is difficult
- ✓ Strong in compression than in tension
- ✓ Use: Make drills, chisels

2. Non-Ferrous

- ✓ **Ferrous metals contain iron and non-ferrous metals do not**
- ✓ Non-ferrous metals include aluminum, copper, lead, zinc and tin, as well as precious metals like gold and silver.
- ✓ Their main advantage over ferrous materials **is their malleability**.
- ✓ They also have no iron content, **giving them a higher resistance to rust and corrosion, and making them ideal for gutters, liquid pipes, roofing and outdoor signs.**
- ✓ Lastly they are non-magnetic, which is important for many electronic and wiring applications

Concrete and concrete structure

E. CONCRETE

It is the mixture formed by mixing cement, Fine Aggregate, Coarse Aggregate and Water in fixed proportion

Concrete=Aggregate [75-80%]+Cement, Water, Air voids[20-25%]

Advantages Of Concrete

1. High **Compressive Strength**
2. Resistance to water
3. Fresh Concrete can be molded to various shape and size
4. Concrete can be pumped and laid
5. Durable
6. Fire resistive
7. Safe from Termite attack

Disadvantages

1. Very Poor Tensile Strength
Fresh Concrete shrinks on drying
In long concrete structure Like embankment, expansion joints are required due to large temperature variation. If not provided, concrete cracks

Usage Of Concrete

1. As bed Concrete below column Footing, Wall Footing
2. For Pavement
3. Building blocks

F. CEMENT

- A binding material, binds Aggregate to form Solid Mass
- Constitutes of Silicates and Aluminates of Lime
- Obtained by burning a mixture of Calcareous(Calcium) and Argillaceous (Clay) materials at high temperature

Classification of Cement

- Hydraulic Cement: sets and hardens by chemical reaction with water

They harden due to hydration, when exposed to water (wet condition).

Example: Portland Cement OPC, PPC

- Non Hydraulic Cement: it does not begin to harden when exposed to water.

Must be kept dry to retain strength

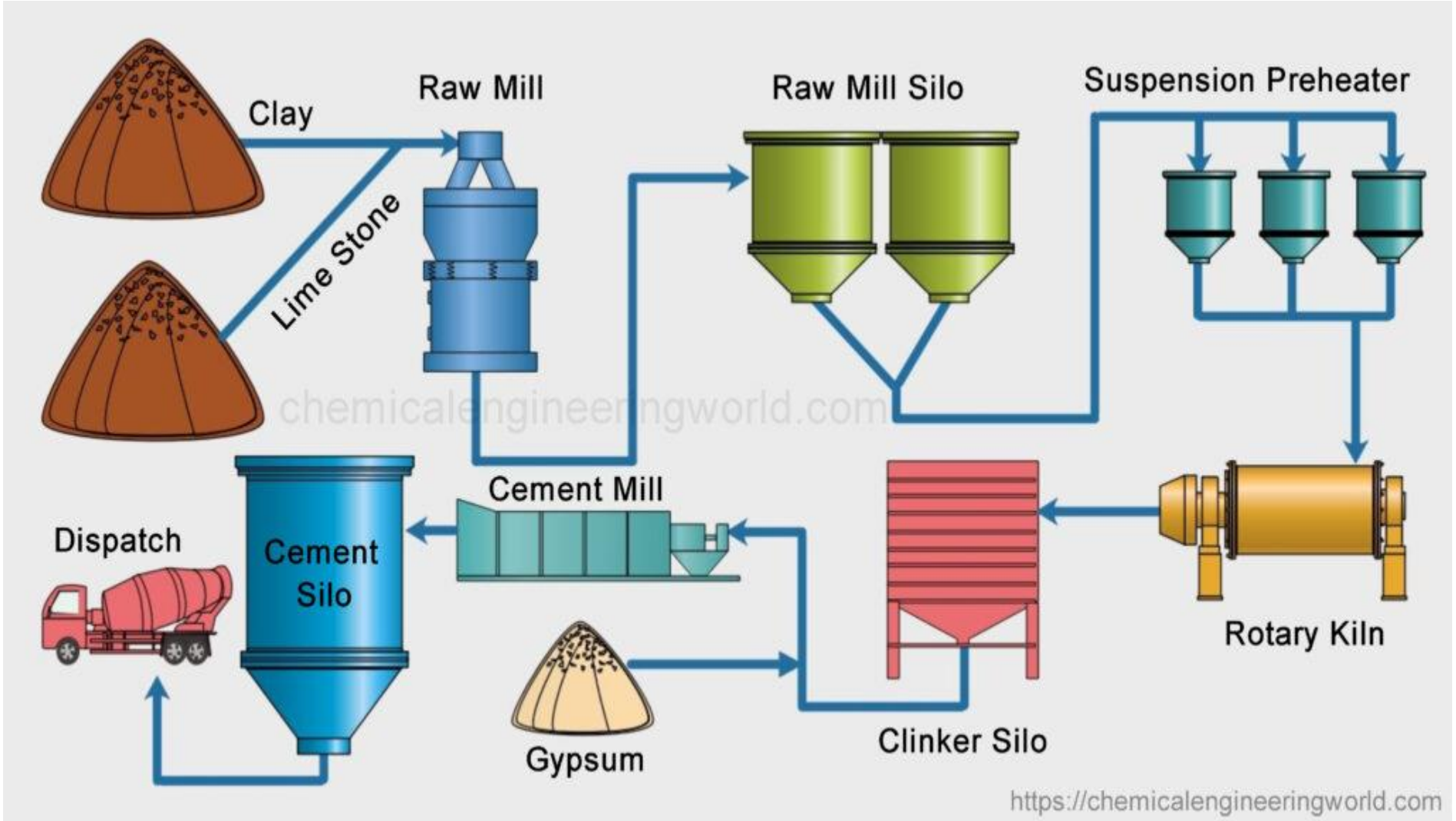
Example: Lime

F. CEMENT

Ingredients	Function	Composition
1. Lime CaO	Controls strength and Soundness (resist volume changes after hardening = soundness)	60-65%
2. Silica SiO_2	Gives Strength, Excess of it cause slow setting	17-25%
3. Alumina Al_2O_3	Quick setting, Excess causes reduction in strength	3-8%
4. Ferrous Oxide Fe_2O_3	Color, Helps to fusion of others	0.5-6%
5. Magnesium Oxide MgO	Color, Hardness, excess cause crack	0.5-4%
6. Sulphur Trioxide SO_3	Sound	1-2%
7. Soda & Potash (Alkalis)	Excess of it causes cracking	0.5-1%

MANUFACTURING OF CEMENT:

1.Mixing
2. Burning
3. Grinding
4. Storage



Manufacture of Cement

1. Heating limestone with Alumina at 1450 degree Celsius in Kiln.
2. Rxn. involved are:

   Limestone: $CaCO_3$—$CaO+CO_2$

   Alumina:$Al_2O_3+SiO_2+Fe_2O_3$

3. This results production of **Clinkers** called

C_3S : (3CaO.SiO2)=Tri Calcium Silicate = **Alite**

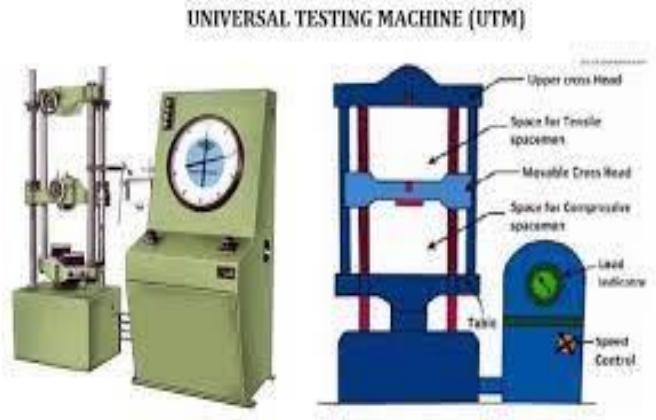
C_2S : (2CaO.SiO2)=Di Calcium Silicate = **Belite**

C_3A :(3Ca0.Al2O3)=Tric Calcium Aluminate =**Celite**

C_4AF :(4CaO.Al2O3.Fe2O3)=Tetra Calcium Alumino Ferrite=**Tetra Felite**

4. Pulverize products of Step 3 to get Cement.

COMPOUND	FUNCTION
C_3S	• About 45% percent • Responsible for early strength of concrete • Rapid hardening cement
C_2S	• About 25% • It is responsible for late strength of concrete
C_3A	• About 12% • Reaction is very fast • Flash set • Gypsum is added to late setting time • No significant strength contribution
C_4AF	• About 10% • No strength contribution • It gives volume to the concrete • Reacts slowly



Properties of Cement

1. Crushing Strength

- 43 grade OPC means that this cement will have 28 days compressive strength of minimum 43 MPa in room temperature (25 degree Celsius)

2. Setting Time

- 30 min to 60 min of setting time for initial setting

Initial Setting definition:

Cement +Water=Sticky Paste

After certain time, it becomes stiff to some extent.

This time is initial setting time.

OPC and PPC Cements

OPC(Ordinary Portland Cement)

- Pulverize Cement Clinkers
- Costly due to expensive clinkers
- Less Finer

PPC(Pozzolana Portland Cement)

- Pozzolana (Ashes, Volcanic) is siliceous material added with clinkers
- Relatively Cheaper
- Finer

Nominal Mix Design

M10=1:3:6=Cement :Sand :Aggregate

M15=1:2:4=C:S:A

M20 = 1:1.5:3

USAGES OF CEMENT

- ❖ Cement Slurry used for filling Cracks in concrete structures.
- ❖ Used for masonry work, Plastering
- ❖ Cement pipes(Cross drainage structures)
- ❖ Footpaths, Courts