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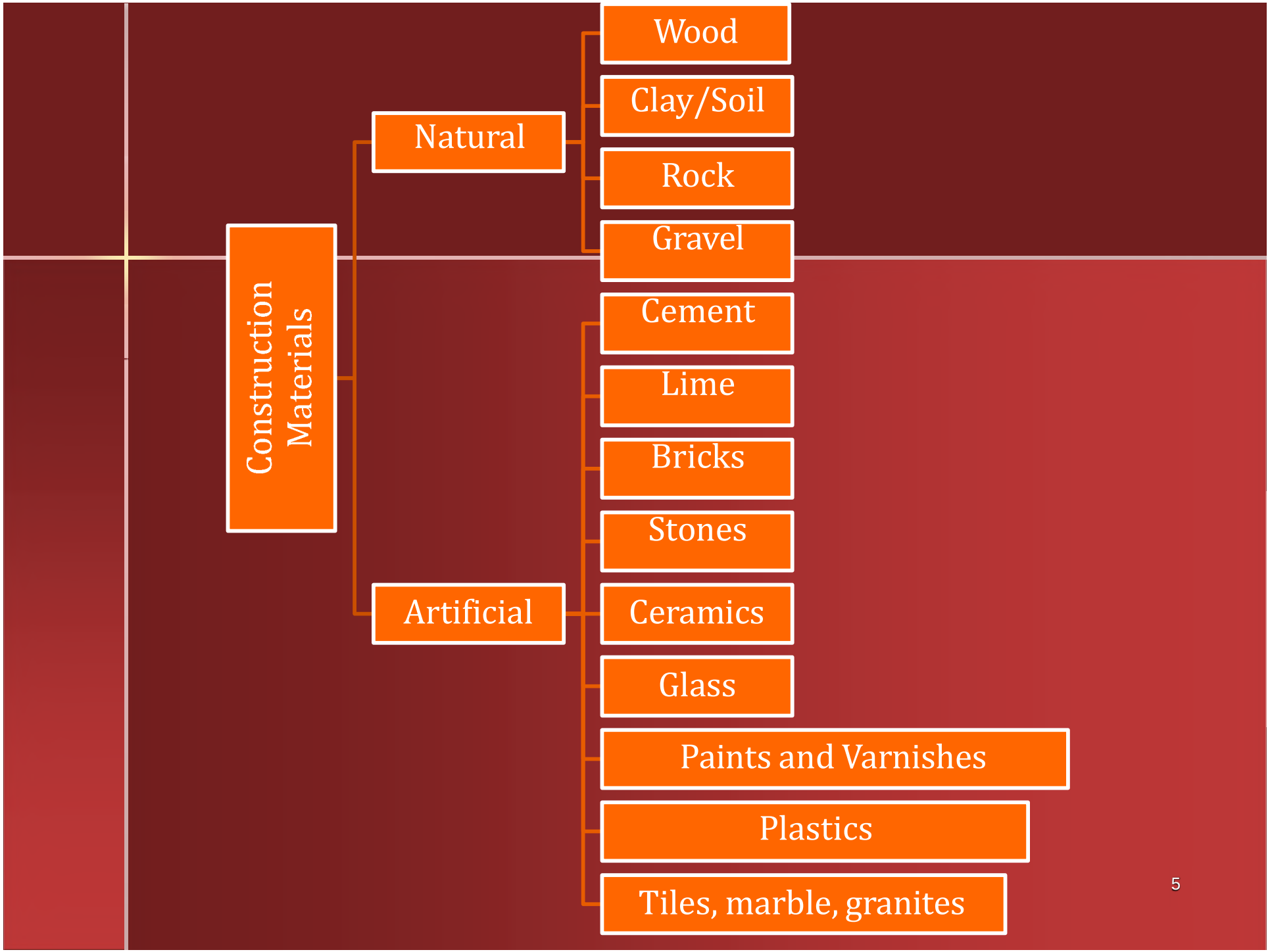
- Construction materials
- Properties of materials
- Stone
- Bricks
- Lime
- Cement
- Sand
- Aggregate

- Mortar
- Concrete
- Other civil engineering materials

- All the building structures are composed of different types of materials.
- These materials are either called building materials or materials of construction.
- The material cost in a building ranges 30 to 50 percent cost of total cost Project.


Construction Materials
Natural
Wood
Clay/Soil
Rock
Gravel
Artificial
Cement
Lime
Bricks
Stones
Ceramics
Glass
Paints and Varnishes
Plastics
Tiles, marble, granites

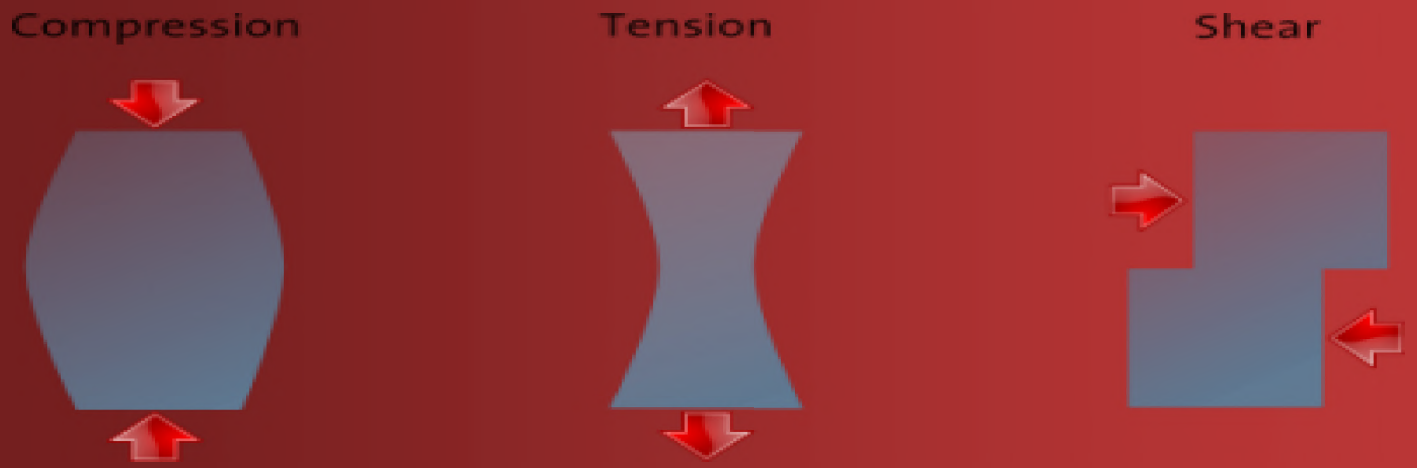
Mechanical properties of materials

1. Strength
2. Elasticity
3. Plasticity
4. Ductility
5. Brittleness
6. Malleability
7. Toughness
8. Hardness
9. Stiffness
10. Creep
11. Fatigue strength

Strength

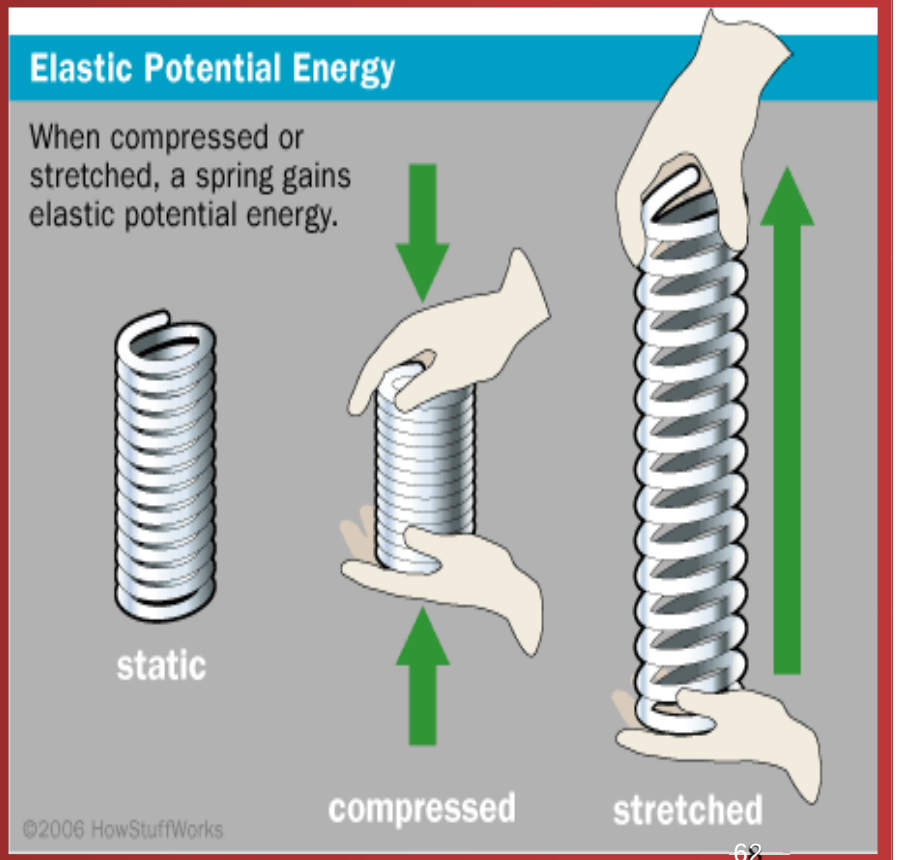
The capacity of material to withstand load is called strength.

- Strength of materials, ability to withstand an applied stress without failure
- Compressive strength, capacity to withstand axially directed pushing forces
- Tensile strength, maximum stress while being stretched or pulled before necking
- Shear strength, the ability to withstand shearing.



- Elasticity

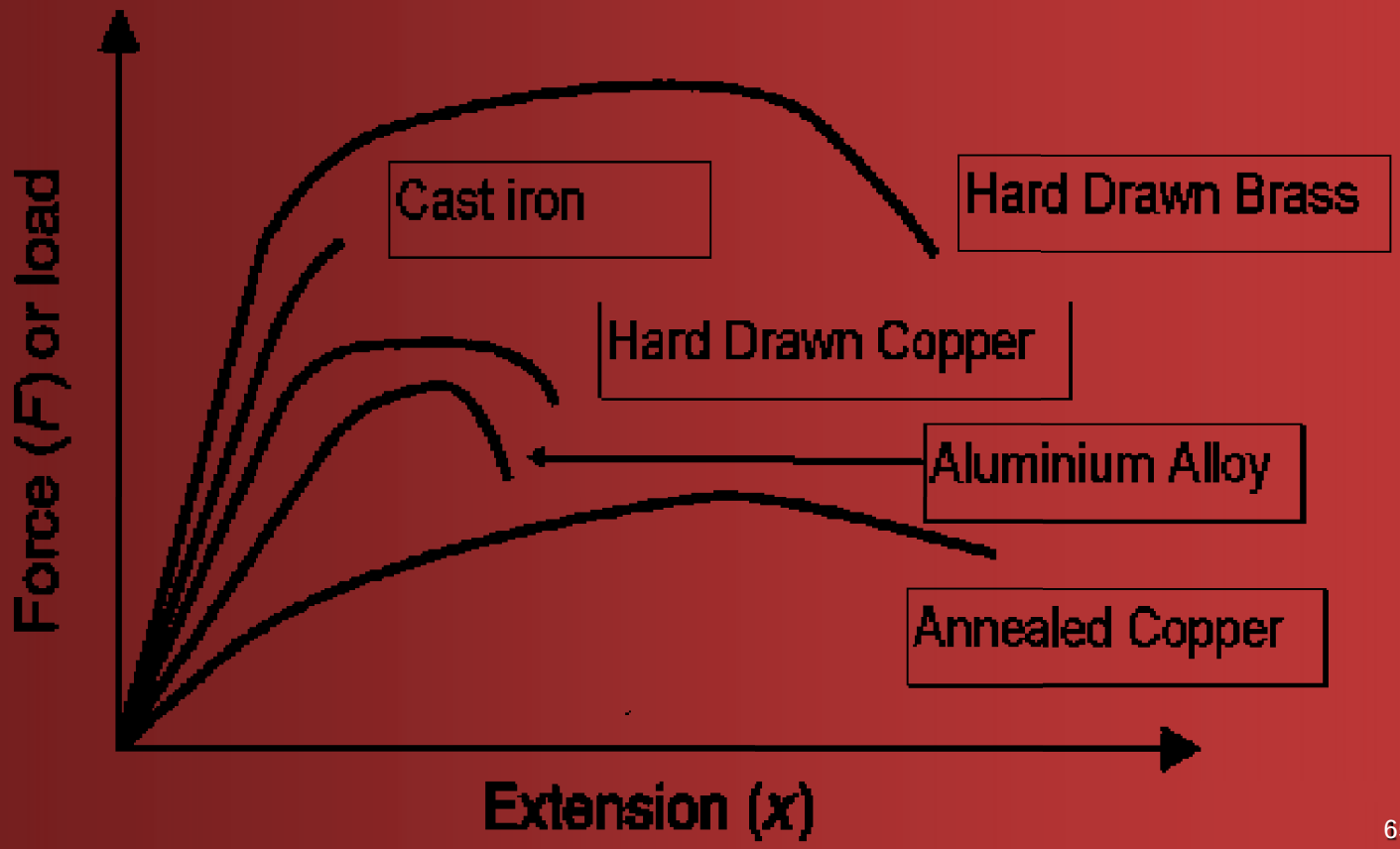
On a material when external load is applied it undergoes deformation and on removal of the load, it returns to it's original shape.



- Plasticity:

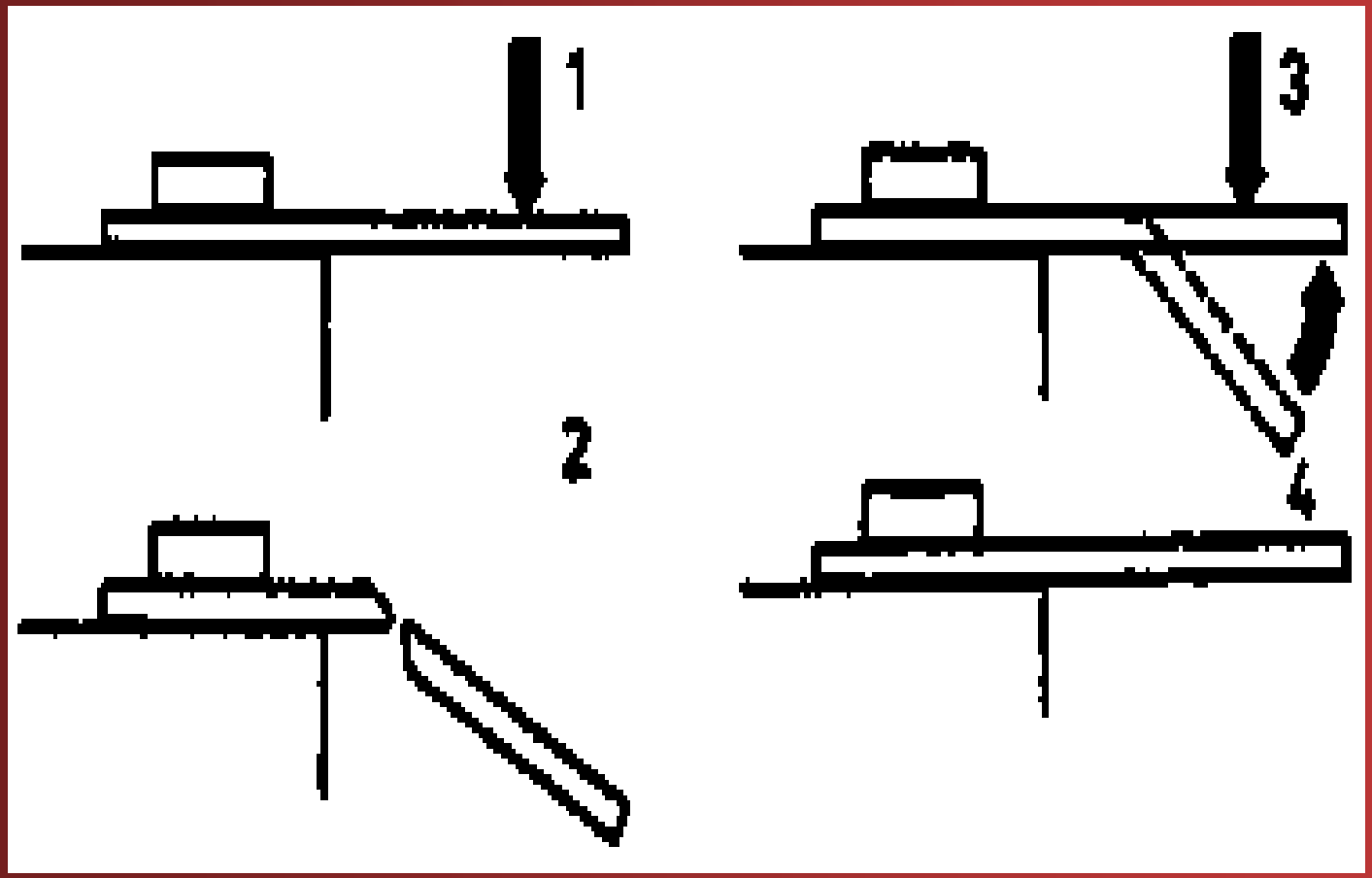
If a material does not regain its original shape, on removal of the external load, its called plastic materials.

- Ductility
- If a materials can undergo a considerable deformation without rupture it is called a ductile materials.
- It is undergo large deformation during tensile test. It is the most suitable material for tension member.
- E.g. steel, copper, wrought iron, aluminum alloys are ductile materials.
- Elongation is more than 15%


Force (F) or load
Extension (x)
Cast iron
Hard Drawn Brass
Hard Drawn Copper
Aluminium Alloy
Annealed Copper

- **Brittleness**

- If a material can not undergo any deformation when some external force act on it and it fails by rupture.
- Stronger in compression and weak in tension.
- C.I, glass, concrete, bricks
- Elongation is less than 5%


1
2
3
4

- Malleability

- Which material can be convert in to thin sheets by hammering.
- Gold, silver, copper, aluminum, Tin, Lead steel etc.

- Toughness

- Capacity of a material to absorb energy before rupture is called toughness.
- Mild steel, wrought iron, etc.

- Hardness

- Resistance of materials to abrasion, indentation, wear and scratches is called hardness.
- C.I is hardest material

- Stiffness

- Force required to produce unit deformation in a material is called stiffness.

- Creep

- Inelastic deformation due to sustained load is known creep.

Physical properties of materials

- Bulk density

$$\rho = \frac{M}{V}$$

- Water absorption
- Permeability
- Durability
- Specific gravity (G)

$$G = \frac{Mass\ of\ solids\ of\ specified\ volume}{Mass\ of\ quall\ volume\ distiled\ water}$$

STONE

- **Classification of Rocks:**

Building stones are obtained from rocks occurring in nature and classified in three ways.

1. Geological classification
2. Physical classification
3. Chemical classification

Geological Classification:

- **Igneous rocks:** Rocks that are formed by cooling of Magana (molten or pasty rocky material) are known as igneous rocks.

  Eg: Granite, Basalt and Dolerite etc.

- **Sedimentary rocks:** these rocks are formed by the deposition of production of weathering on the pre-existing rocks.

  Examples: gravel, sandstone, limestone, gypsum, lignite etc.

- **Metamorphic rocks.** These rocks are formed by the change in character of the pre-existing rocks. Igneous as well as sedimentary rocks are changed in character when they are subject to great heat and pressure. Known as metamorphism.

  Examples: Quartzite, Schist, Slate, Marble and Gneisses.

- **Physical Classification:**
- **Stratified Rocks:** These rocks posses planes of stratification or cleavage and such rocks can be easily split along these planes.

  Ex: sedimentary rocks
- **An stratified rocks:** The structure may be crystalline granular or compact granular.

  Examples: Igneous rocks and Sedimentary rocks affected by movements of the earth.
- **Foliated Rocks:** These rocks have a tendency to split up in a definite direction only.

  Ex: Metamorphic rocks.

- **Chemical Classification:**
- **Siliceous rocks:** In these rocks, silica is predominates. The rocks are hard; durable and not easily effected by weathering agences.

  Ex: Granite, Quartzite, etc.
- **Argillaceous Rocks:** In these rocks, clay predominates. The rocks may be dense and compact or may be soft.

  Ex: slates, Laterites etc.

- **Calcareous rocks:** In these rocks, calcium carbonate predominates. The durability to these rocks will depend upon the constituents present in surrounding atmosphere.

  Ex: Lime Stone, marble etc.

Uses of stones:

1.Structure: Stones are used for foundations, walls, columns, lintels, arches, roofs, floors, damp proof course etc.

2.Face works. Stones are adopted to give massive appearance to the structure. Wall are of bricks and facing is done in stones of desired shades. This is known as composite masonry.

3.Paving stones: These are used to cover floor of building of various types such as residential, commercial, industrial etc. They are also adopted to form paving of roads, foot paths etc.

4.Basic material: Stones are disintegrated and converted to form a basic material for cement concrete, morum of roads, calcareous cements, artificial stones, hallow blocks etc.

5.Misalliances: Stones are also used for (i) ballast for railways (ii) flux in blast furnace (iii) Blocks in the construction of bridges, piers, abutments, retaining walls, light houses, dams etc.

Qualities of a good building stone

- **Crushing strength:** For a good building stone, the crushing strength should be greater than l000kg per cm2.
- **Appearance**: Good building stone should be a uniform colour, and free from clay holes, spots of other colour bands etc capable of preserving the colour for longtime.
- **Durability**: A good building stone should be durable. The factors like heat and cold alternative wet and dry, dissolved gases in rain, high wind velocity etc affect the durability.
- **Fracture**: For good building stone its fracture should be sharp, even and clear.

- **Hardness**: The hardness greater than 17, treated as hard used in road works. It is between 14 to 17, medium hardness, less 14 said be poor hardness.
- **Percentage wear**: For a good building stone, the percentage wear should be equal to or less then 3 percent.
- **Resistance to fire**: A good building stone be fire proof. Sandstone, Argillaceous stone resists fire quite well
- **Specific gravity**: For a good building stone the specific gravity should be greater then 8.7 or so.
- **Texture**: A good building stone should have compact fine crystalline structure should be free from cavities, cracks or patches of stuff or loose material.

- **Water absorption:** For a good building stone, the percentage absorption by weight after 24 hours should not exceed 0.60.

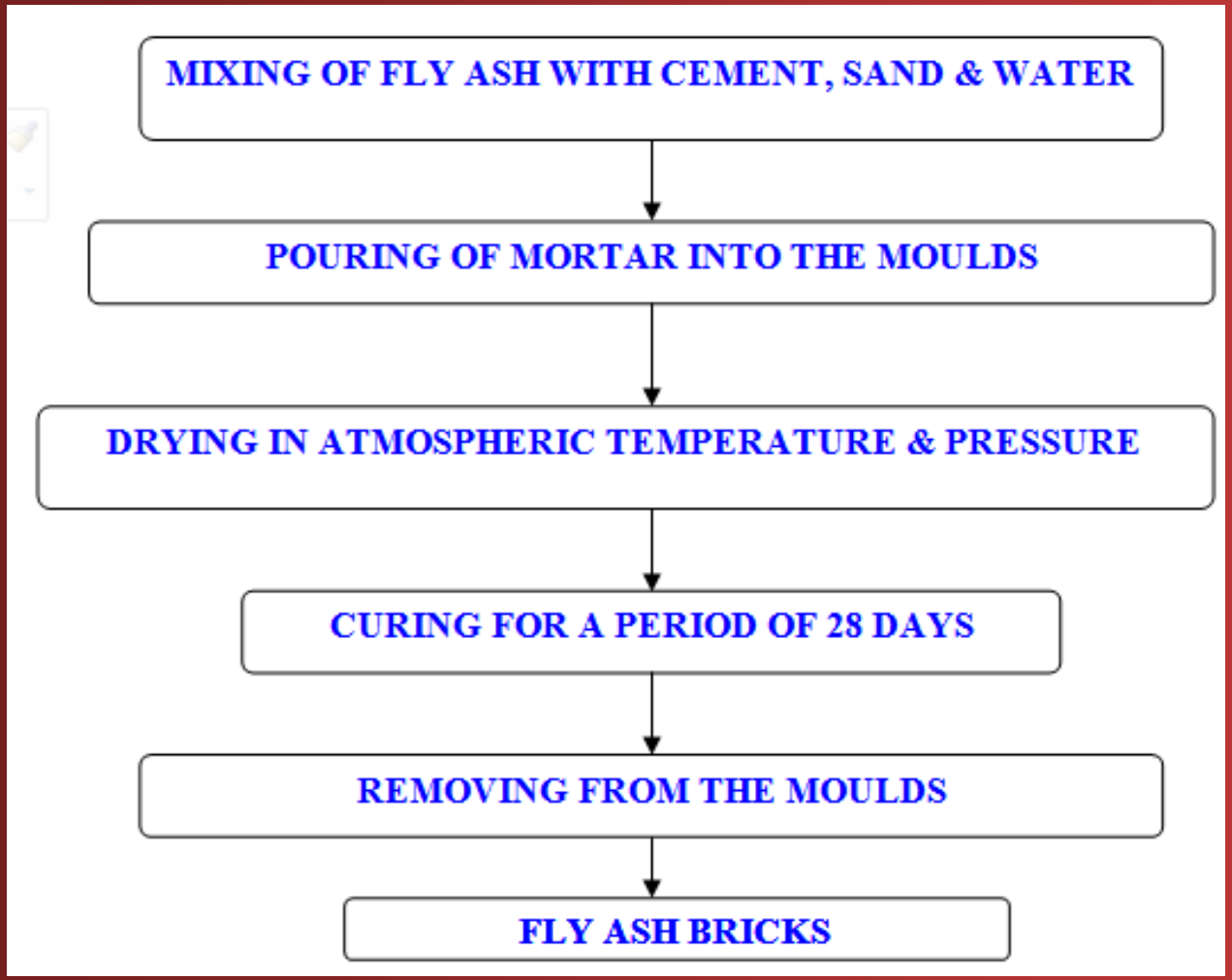
BRICKS

- Bricks are obtained by moulding clay in rectangular blocks of uniform size and then by drying and burning these blocks.

Composition

Composition	Percentage (%)
Alumina	20-30
Silica	50-60
Lime	2-5
Magnesia	0.1
Iron oxide	5-6

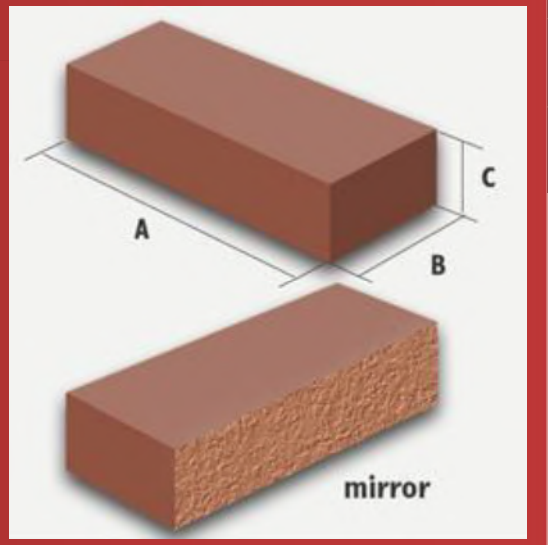
Brick Manufacturing



Types of Bricks

1. Conventional / traditional bricks
2. Standards bricks

Type	A	B	C
Conventional	23	11.4	7.5
Standard	19	9	9



All dimension in Cm
Size of Frog is 8*4*2 Cm

Qualities of Good Brick:

- Bricks should be table moulded, well burnt in kilns, copper coloured, free from cracks and with sharp and square edges.
- Bricks should be uniform shape and should be of standard size.
- Bricks should give clear ringing sound when struck each other.
- Bricks should not absorb water more than 20 percent by weight for first class bricks and 22 percent by weight for second class bricks, when soaked in cold water for a period of 24 hours.

- Bricks should be low thermal conductivity and they should be sound proof.
- Bricks should not break when dropped flat on hard ground from a height of about one meter.
- No brick should have crushing strength below 55kg/cm2

Bricks are classified

- 1. Un-burnt or sun dried bricks
- 2. Burnt bricks
    - a. First class bricks
    - b. Second class bricks
    - c. Third class bricks
    - d. Fourth class bricks

- As per IS1077-1957 & 1970

1. Grade A – A class < =140kg/cm2
2. Second class bricks – grade B <= 70kg/cm2
3. First class bricks – grade A < =105kg/cm2
4. Class III bricks – grade C average 35kg/cm2

LIME

- The product remained after removal of moisture and carbon dioxide from the limestone by the process of calcination is termed as lime.

$$CaCO_3 \longrightarrow CaO + CO_2$$

Lime + Sand = Lime mortar

Lime + Sand + C.A = Lime Concrete

Types of Lime

1. Fat lime (Pure lime)
2. Hydraulic lime (Which sets under water)
3. Poor lime (Impure lime)

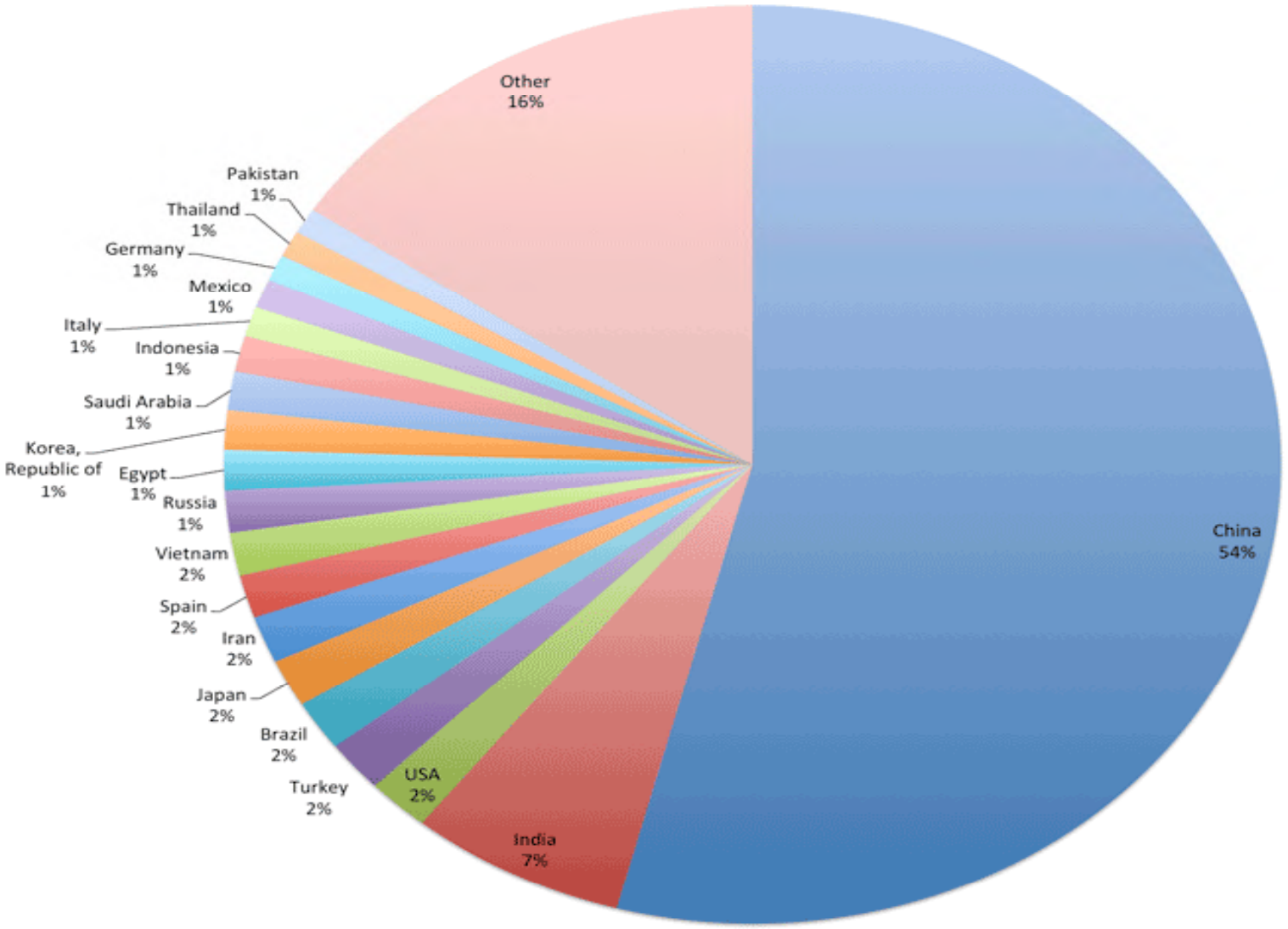
Properties of good lime

- Good plasticity
- Easily workable
- Stiffens quickly
- Good moisture resistance
- Low shrinkage

Cement

- which acts as a binding agent for materials natural cement (Roman Cement) is obtained by burning and crushing the stones containing clay, carbonates of lime and some amount of carbonate of magnesia.

- cement is obtained by burning at very high temperature a mixture of calcareous and argillaceous materials in correct proportion


Cement Production 2010
Other
16%
Pakistan
1%
Thailand
1%
Germany
1%
Mexico
1%
Italy
1%
Indonesia
1%
Saudi Arabia
1%
Korea,
Republic of
1%
Egypt
1%
Russia
1%
Vietnam
2%
Spain
2%
Iran
2%
Japan
2%
Brazil
2%
Turkey
2%
USA
2%
India
7%
China
54%

Ingredients and function

Ingredients	Percentage (%)	Function
Lime (cao)	60-67	Provide strength
silica (Sio2)	17-25	Provide strength
Aluminca (Al2 O3)	3-8	Quick setting
Iron Oxide (Fe2 O3)	0.5-6	Colour, hardness, strength
Magnescia (Mgo)	0.5-4	Hardness, coiour
K2O, Na2o (Alkalies)	0.3-1.2	Sulphate resistance
SO3 (Sulphates)	1-3	Increase setting time

Bogne's compounds

- Tri calcium silicate – C_3S
- Dai calcium silicate – C_2S
- Tri calcium Aluminate – C_3A
- Tetra calcium Aluminoferirite – C_4AF

Functions of Ingradients

- **Lime**: Lime is the important ingredient of cement and its proportion is to be maintained carefully.
- If lime is in deficiency the strength of the cement is decreased and it causes cement to set quickly

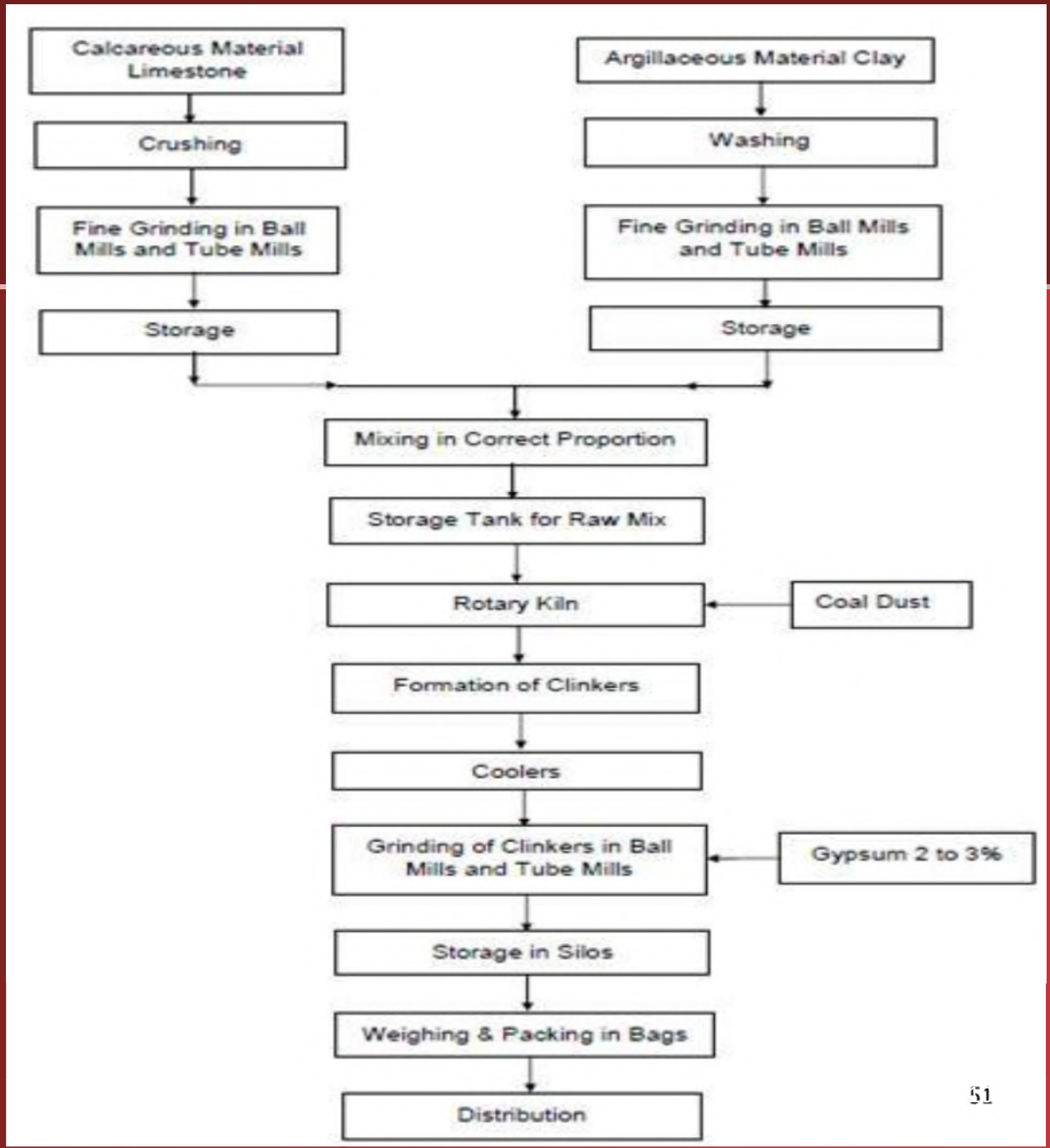
- **Silica**: This also an important ingredient of cement and it gives or imparts quick setting property to imparts strength to cement

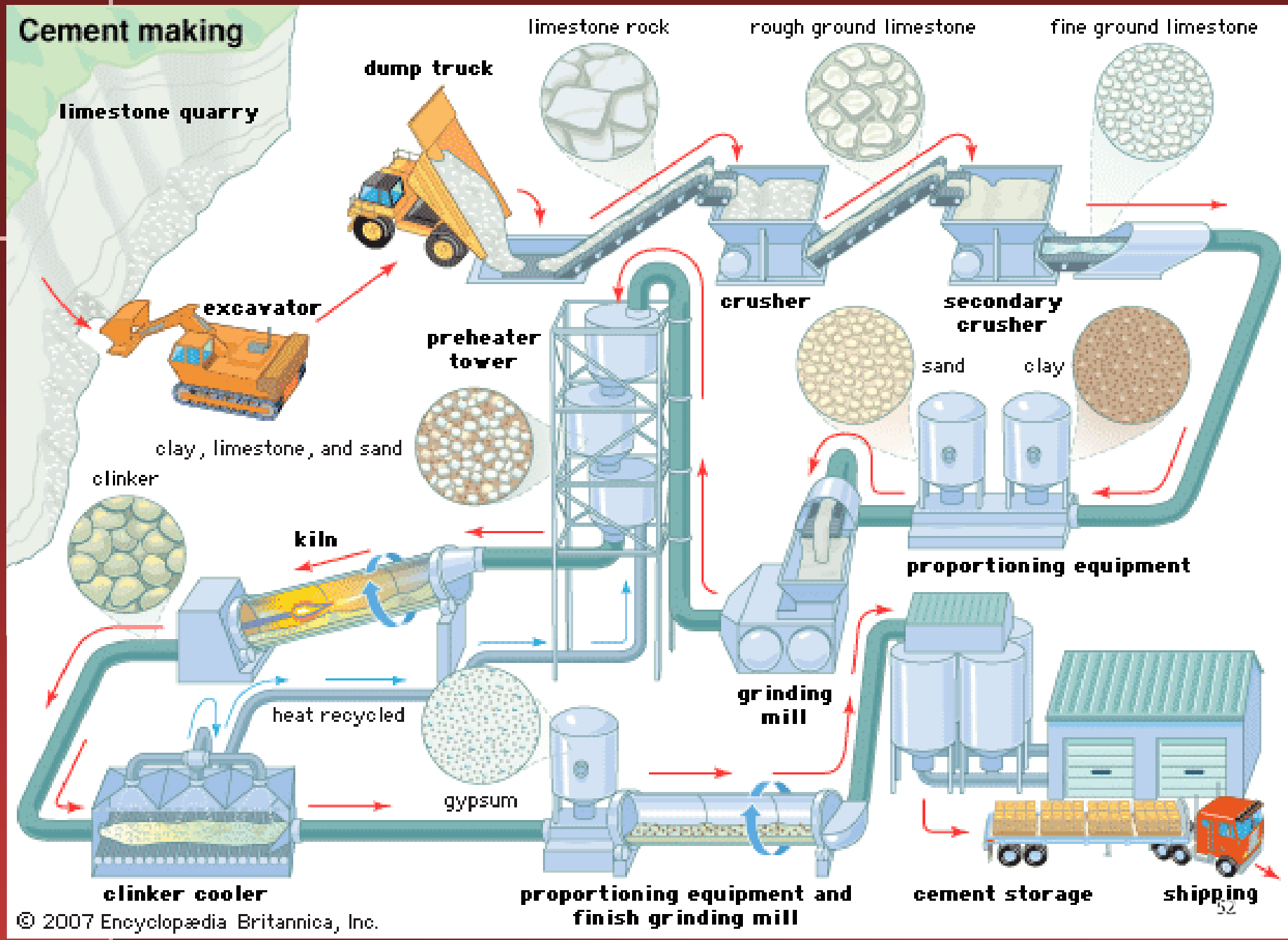
- **Alumina**: This ingredient imparts quick setting properly to cement.
- **Calcium Sulphate**: This ingredient is in the form of gypsum and its function is to increase the initial setting time of cement.
- Magnesia: The small amount of this ingredient imparts hardness and colour to cement

- **Sulphur**: A very small amount of sulphur is useful in making sound cement

- **Alkalies**: Most of the alkalies present in raw material are carried away by the flue gases during heating and only small quantity will be left.

Manufacturing process of Cement




Cement making
limestone quarry
dump truck
limestone rock
rough ground limestone
fine ground limestone
crusher
secondary crusher
excavator
preheater tower
sand
clay
clay, limestone, and sand
clinker
kiln
proportioning equipment
grinding mill
heat recycled
gypsum
clinker cooler
proportioning equipment and finish grinding mill
cement storage
shipping
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Types of cement

1. Ordinary Portland cement (33, 43, 53 Grade)
2. Rapid hardening cement
3. Extra rapid hardening cement
4. Quick setting cement
5. Low heat cement
6. Sulphate resistance cement
7. Super sulphate cement
8. Portland pozzolana cement
9. Portland slag cement
10. Coloured cement (White)

33 grade means minimum compressive strength at 28 days is 33 N/mm2

11. Hydrophobic cement
12. Air entering cement
13. Masonry cement
14. Oil well cement
15. Expensive cement
16. High alumina cement
17. Water proof cement
18. Very high strength cement

Uses of Cement

- Cement mortar for masonry work, plaster, pointing etc.
- Concreter for laying floors, roofs and constructing lintels, beams, weather sheds, stairs, pillars etc.
- Construction of important engineering structure such as bridges, culverts, dams, tunnels storage reservoirs, light houses, deckles etc.
- Manufacture of pre cast pipes, piles, garden seats, artificially designed urns, flowerpots, dustbins, fencing posts etc.
- Preparation of foundations, watertight floors, footpaths etc.

SAND

- Is a natural product obtained from pit, river beds, shores, sea beds etc.
- It is I form of silica (SiO2)

Types of Sand

1. **Natural sand:** obtained from pit, river and sea bad.

2. **Artificial sand**: Formed by decomposition of sound stone due to various weathering effects.

- **Based on Size**

1. Fine sand: fineness modulus 2.2 – 2.6

2. Medium sand : fineness modulus 2.6 – 2.9

3. Coarse sand : fineness modulus 2.9 – 3.2

Characteristics of sand

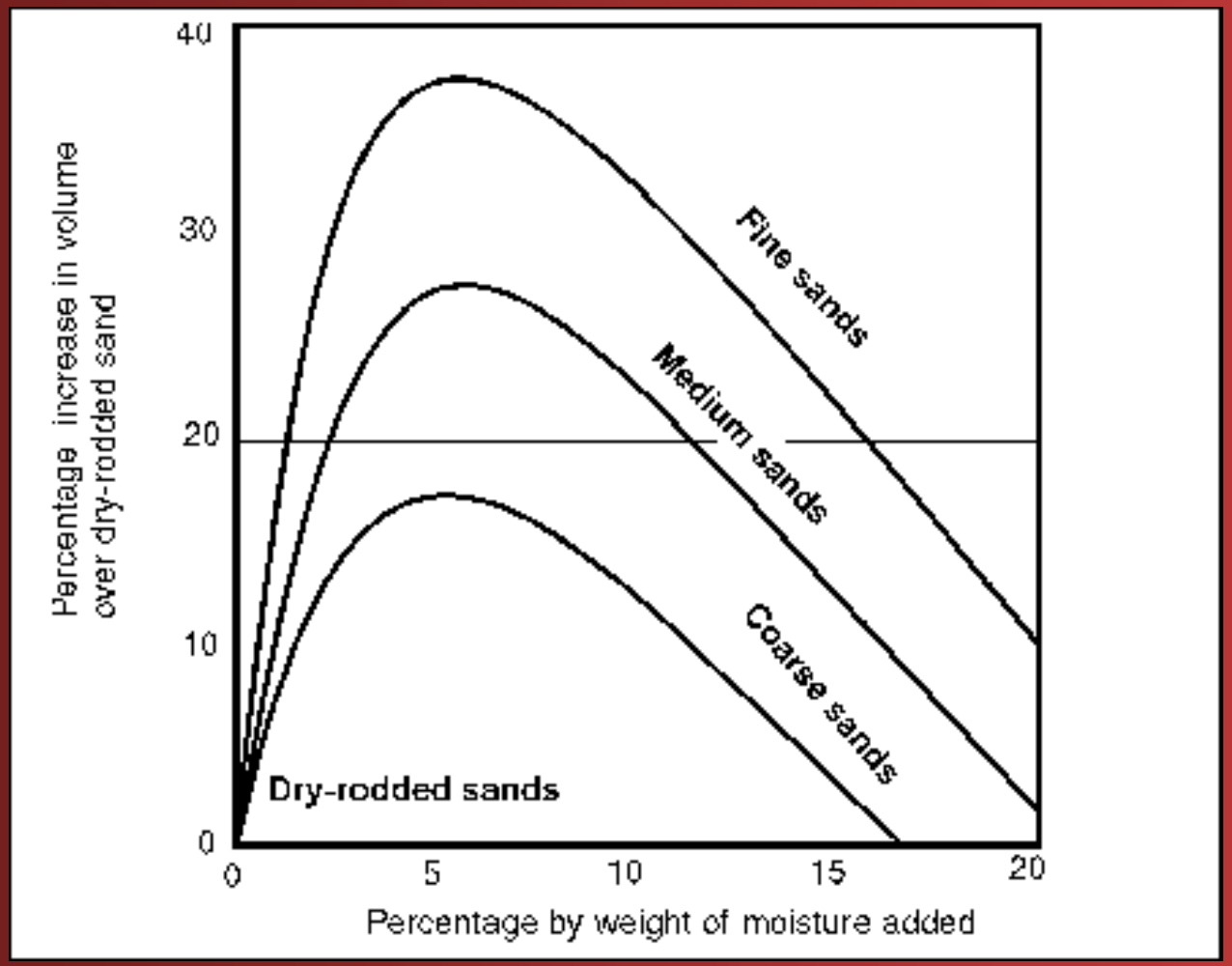
- It should be hard and durable.
- It should be chemically inert.
- It should be clean and coarse. It should be free from organic matter.
- It should contain sharp, angular and durable grains.
- It should not contain salts, which attract the moisture from atmosphere.
- It should be well graded.

Use of sand

- Used in cement mortar, lime mortar, PCC, RCC, etc.
- In flooring.
- Plinth filling.

Bulking of Sand

- The presence of moisture in sand increases the volume of sand.
- This is due to fact that moisture causes film of water around the sand particles which result in the increase of volume of sand.
- For a moisture content of 5 to 8 percent, the increase in volume may be about 5 to 8 percent, depending upon the grading of sand.


40
30
20
10
0
0
5
10
15
20
Percentage increase in volume over dry-rodded sand
Percentage by weight of moisture added
Fine sands
Medium sands
Coarse sands
Dry-rodded sands

AGGREGATE

- Aggregate are the important constitute in concrete.
- They give body to concrete, reduce shrinkage and effect economy.
- It is 70 – 80 % of total volume of concrete.
- Aggregate were consider chemically inactive and active as a filler material.

Classification of Aggregate

- **Based on weight.**

1. Normal wt. : density of concrete is produced from 2300 to 2600 kg/m3, e.g.- Sand, Gravel, granite, etc.
2. Light wt. :density of concrete is produced from 1200 to 1850 kg/m3, e.g.- Foamed slag, rice husk,etc.
3. Heavy wt. :density of concrete is produced from 4000 to 5000 kg/m3, e.g.- Barite, magnetite, hematite, etc.

Based on size

- Fine aggregate : size <= 4.75 mm

  Bulking is less

  e.g. Sand, rock dust

- Coarse aggregate : size > 4.75 mm

  Bulking is more

  e.g. Gravel

- Based on shape

1. Rounded
2. Irregular
3. Angular
4. Flaky

- Based on structure

1. Glassy
2. Smooth
3. Granular
4. Crystalline
5. Honey combed and porous

Requirement of good aggregate

- Should be hard, strong and durable.
- Free form organic impurities.
- Free from grass and roots.
- Clay content should not exceed 4 %
- Good soundness.
- Well graded.

Use of C.A

- Filler material in PCC and RCC.
- Used as base coarse material for road works.
- Used as railway basalt.

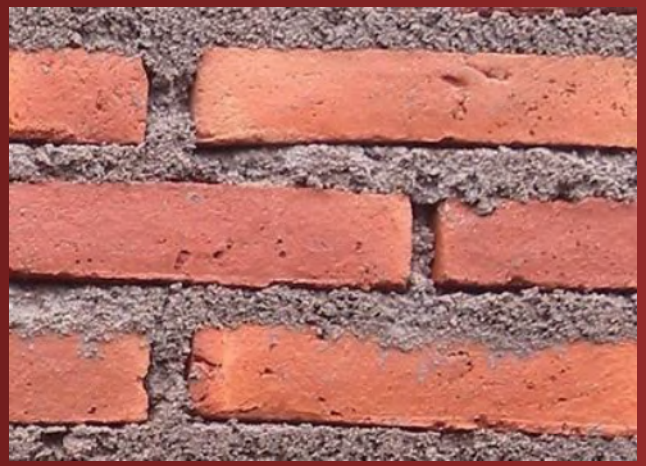
Test on Aggregate

1. Aggregate crushing value test
2. Aggregate impact value test
3. Aggregate abrasion value test
4. Specific gravity test
5. Bulk density test
6. Absorption and moisture content test
7. Fineness modulus test
8. Flakiness index
9. Elongation index

MORTAR

- The term mortar is used to indicate a paste prepared by adding required quantity of water to a mixture of binding material like cement or Lime and fine aggregates like sand.

- Mortar = Cement/Lime + FA + Water



Types of mortar

1. Cement mortar : in this motor, Cement is used as binding material. Depending upon the strength required and importance of work, the proportion of cement to sand varies from 1:2 to 1:6 or more. it is stronger than lime mortar and is used most of civil engineering work. Like masonry, plaster, pointing etc.

2. Lime mortar : in this motor, lime is used as binding material. Lime may be fate lime or Hydraulic lime. Fat lime mortar 1:2 to 1:3 and hydraulic lime mortar may be1:2 by volume.

3. Mud mortar: For cheap work use fibrous material like gober.

Properties of good mortar

- It should be capable of developing good adhesion with the building units such as bricks, stones etc.
- It should be capable of developing the designed stresses.
- It should be capable of resisting penetration of rainwater.
- It should be cheap.
- It should be durable.
- It should be easily workable.
- It should not affect the durability of materials with which it comes into contact.

Uses:

- To bind the building units such as bricks, stones etc.
- To carry out painting and plaster works on exposed surfaces of masonry.
- To form an even bedding layer for building units.
- To form joints of pipes.
- To improve the appearance of structure.

CONCRETE

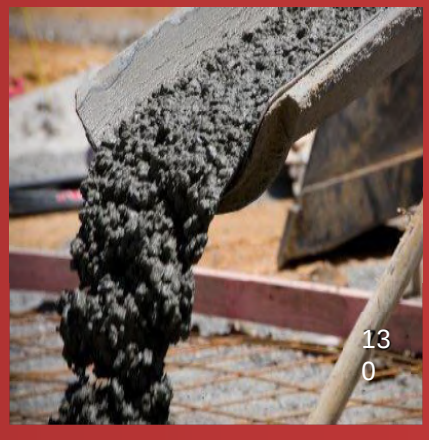
- Cement concrete is a mixture of cement, sand, pebbles or crushed rock and water.
- When placed in the skeleton of forms and allowed to cure, becomes hard like a stone.
- Cement concrete is important building material because of the following reasons.

1. It can be moulded into any size and shape of durable structural member.
2. It is possible to control the properties of cement concrete.
3. It possesses adequate plasticity for mechanical working.

Ingredients in concrete

1. Binding material like cement, lime, etc.
2. FA (Sand)
3. CA
4. Water
5. Admixture

Concrete = Cement + FA + CA + Water + Admixture



Preparation of concrete mix:

- **There are two types of concrete mixing**

(i) Hand mixing

(ii) Machine mixing

1. Continuous mixers
2. Batch mixers

Properties of Concrete

- It has high compressive strength.
- It is free from corrosion.
- It hardens with age
- It is proved to be economical than steel
- It binds rapidly with steel and it is weak in tension
- It forms a hard surface, capable of resisting abrasion stresses.

- **For Fresh concert**

- Good workability
- Segregation should not take place while transporting and placing.
- Bleending should not take place after placing.
- Concrete surface should not be hash.

- **For Harden concrete**
- Good compressive strength
- Impermeability
- Good durability
- Good resistance to wear and tear
- Good resistance to sulphate attack.
- Good impact resistance.

- **Drawback :** Low tensile strength

Concrete classification

- Plain cement concrete (PCC)
- Reinforced cement concrete (RCC)
- Prestressed concrete (PSC)
- Precast concrete

Concreting Operation

1. Batching
2. Mixing
3. Transporting
4. Placing
5. Compaction
6. Curing
7. Finishing

Advantages of concrete

- It possesses high compressive strength
- It is durable and hard
- It is economical than steel
- It can easily moulded into any desired shape.
- Good water tightness
- No weathering effects
- It required little maintenance

Dis-Advantages of concrete

- It has low tensile strength
- It is a brittle materials
- It develops shrinkage crack
- Concrete work requires skilled supervision
- Repair of concrete work is difficult
- It requires 14 to 28 days for hardening

OTHER CIVIL ENGINEERING MATERIALS

- Ferrous and non ferrous materials
- Ceramic
- Timber
- Paints and Varnishes
- Plastics
- Glass
- Fly ash