Steel

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→ Carbon content: 0.25 – 1.5 %
→ Steel is alloy of carbon and iron
→ As the carbon content gets higher, it becomes harder & tougher.
→ Elastic, malleable & ductile
→ Very high compressive as well as tensile strength.
→ doesnot affected by corrosion.
→ Heat treatment can be done.

Types of steel:- (only carbon is controlling component)

① Carbon steel
- → High Carbon Steel
- → Medium Carbon steel
- → Low Carbon steel

② Alloy steel
- ↳ cobalt steel
- ↳ Copper steel
- ↳ Manganese steel
- ↳ Nickel steel
- ↳ Vanadium steel
- ↳ Stainless steel

** Carbon Steel

① Low Carbon Steel: (Mild steel)
→ Carbon contain 0.15% to 0.3%
→ Elastic, tough, malleable & ductile
→ Most abundant grade of steel.
→ good tensile & compressive strength.
→ Can be magnetized permanently.
→ can be easily forged, welded & riveted.
→ Heat treatment isnot possible
→ Affected by corrosion.

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Uses
→ Used in all structural Works
→ Used as reinforced bars in RCC
→ Used as different sections (I section, T section etc)

② Medium carbon steel:-
→ Carbon content 0.3% to 0.8%
→ Elastic, malleable, ductile but much tougher than Mild steel.
→ good tensile & compressive strength.
(Compressive strength greater than Mild steel but tensile strength less than Mild steel)
→ Can be magnetized permanently.
→ Heat treatment is possible but difficultly.
→ Affected by corrasion. → Used in all structural work.

③ High Carbon Steel
→ carbon content 0.8% – 1.5%
→ More tough & elastic than mild steel.
→ Less tensile strength but very good compressive strength
→ Can be permanently magnetized.
→ Heat treatment is possible easily.
→ Difficult to forged, welded & riveted.
→ Affected by corrasion.

Uses
→ Making drills, files, chisels, hard part of machines.

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* Alloy Steel:-
→ steel is mixed with alloying elements (such as manganese, silicon, nickel, titanium, copper, chromium, aluminium etc) to change the properties of steels.

* Types of alloy steel:-

① Cobalt Steel:-
→ Cobalt + steel
→ Used in cutting tools.

② Copper steel:-
→ Copper + steel
→ Special property of resisting the effect of atmosphere.

③ Manganese steel:-
→ Manganese + steel
→ increase hardness, toughness & strength.

④ Nickel steel:-
→ Nickel + steel
→ Used in making survey tapes, clock, pendulum

⑤ Vanadium Steel
→ vanadium + steel
→ Used for making tools, shafts of aeroplanes, automobile.

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* Heat treatment of steel:-

→ The process of heating & cooling the steel under controlled condition to change the properties of steel.

→ Steps:-

Heating the metal slowly.
Hold the temp of metal for some period.
Cooling the metal to room temperature.

* Purpose / Objective of Heat treatment

→ To change the strength & hardness
→ To reduce increase resistance to corrosion
→ Increase workability
→ Improve machinability.
→ Refine grain size.
→ Improve ductility & toughness.

* Methods of Heat treatment of steel

↳ Annealing
↳ Normalizing
↳ Quenching
↳ Case hardening
↳ Tempering.

* Rolling:- Metal forming process, in which metal stock is passed through a pair of rolls.

cold rolling:- temp of metal below its crystallization temp
hot rolling:- temp of metal above its crystallization temp.

Material is the bases for Civil engineer.

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⑥ Stainless steel (Fe + Cr + Ni)

→ The steel we propably see most often is stainless steel.
→ Contain more than 12% of chromium.
→ Chromium forms dense layer of oxide around a metal surface and high resistance to corrosion.
→ High percentage of Chromium & Nickel.
→ Easy to clean, polish & sterilize.
→ strong, hard & tough, machinability.

* Types of stainless steel:-

① Austenitic Stainless Steel:-
→ Highest corrosion resistance, non magnetic
→ Can be hardened only by cold work.
→ Most of the stainless steels fall in this category.
→ Used in food processing equipment, kitchen utensils & piping

② Ferritic stainless steel:-
→ Magnetic & can be hardened by cold work.
→ Contain less amount of Nickel, so it is cheaper than austenitic steel.

③ Martensitic stainless steel:-
→ Magnetic & heat treatable.
→ They are more hardest stainless steel.
→ Nickel content is also small.
→ Used in knives, cutting tools, dental & surgical equipments.

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Civil Engineering Materials:-

Introduction:-

The material which have been used in the field of civil engineering like stone, bricks, timber, steel, lime, cement, metals etc by civil engineer to construct safe, stable, and economical structure.

Construction materials deal with the study of materials in respect of:
- Sources and composition of materials
- properties of materials
- Manufacturing methods and testing.
- Utility of material as per engineering and technology.
- Modern techniques which is efficient, economical and long lasting for material selection and handling for safer design of structures & machine etc.

Scope of the subject:-

- The basic concern of a civil engineer is the design, construction, supervision & maintainance of different types of structures such as buildings, bridges, canals, roads etc. A key element in the field practice is to deal with different types of materials. Thus study of construction material is the bases for civil engineer.

- As a civil engineer, he/she should have knowledge about drawing, detail specification, selection of materials, storage, sampling and testing etc. Thus for the successful completion of the projects, he/she should study the aspects of materials and ther application in construction.
- Engineering materials have a course, undergone continuing evolution and have improved considerably since the early events. In fact the devlopment of materials used for engineering purposes has experienced unprecedented growth over the last few decades and thus engineering materials have truly become an esserntial part of modern science and technology.
- In the field of modern engineering and technology semiconductor, polymers, fiberglass, other reinforced materials etc, are rapidly becoming more reliable due to high strength, high weight, high temperature resistance, thermal resistance, shock resistance, radiation protection, oxygen & water production, electrical power etc.
- The scope and application of construction materials is very important in this modern age due to the advancement of science and technology.

* Selection Criteria of Construction Material:-
Factors affecting the selection of materials are

a) Performance Requirements:
The material of which a part is composed must be capable of performing the part's function without failure for example a component part to be used in oven must be of that material which can withstand high temperature.

b) Material releability:-
A material chosen should be reliable. Reliable means the material remain stable for intended life without failure.

c) Safety:-
A material must safely perform its function.

d) Physical Attributes:-
physical attributes such as configuration, size, weight and appearance sometimes also serve functional requirements.

e) Environmental Condition:-
Environment strongly influences service performance, humidity, water or chemicals can cause corrosion and failure of materials.

f) Availability:-
A material must be readily available and should be available in large enough quantity for intended application.

g) Economic factors:-
What will the finished product cost?
A material may be found that has the ideal set of properties but is prohibitively expensive.

h) Disposability and Recyclables:-
Materials should be easily disposable & recyclable.

Types of Civil Engineering materials:-

a) On the basis of existence / occurence
i) Natural materials:-
The material which are naturally available in nature is called natural materials.
Eg:- stones, wood, clay, marbles.

ii) Artificial Materials:-
The material which are formed & processed by human, not naturally available is called artificial materials.
Eg:- Cement, lime, polymers, plastics, fiber glass etc.

b) Depending upon the use of materials to which they use.
i) Structural material:- steel, brick
ii) Aesthetic material:- tiles, paints, marble
iii) Special material:- sanitory fixtures, pipe fittings etc.

c) Depending upon the metallurgy
i) Metals - aluminium, copper, gold, silver, steel
ii) Non metal - stone, brick etc.

d) Depending upon composition of materials.
i) Metals and alloys
- metals are opaque, lustre elements that are good conductors of heat and electricity.
- They are malleable and ductile.
- Alloys are produced by melting or sintering of two or more metals and non-metals together

ii) Ceramics:-
- Non-metallic solid made of inorganic compounds such as oxides, nitrates, borides and carbides.
- Formed by application of pressure and temperature.
- used in manufacture of pottery, porcelain, cemnt, silicate glass.

iii) Polymers:-
- Basic constituent as carbon and hydrogen
- Combination of large monomer unit
eg:- plastic, synthetic rubbers, pvc, polyethene

iv) Composites:-
- Two types of materials combine with each other may compose a third material with same different properties known as composites.
- High compressive & tensile strength.
- Eg:- RCC, fiberglass, wire glass.

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* Properties of civil Engineering Materials:-

a) Physical properties:
The properties that shows physical status of the materials is called physical properties.

i) Melting point:
It is defined as temperature at which the solid and liquid phases can exist in stable equilibrium.

ii) Boiling point:
It is the temperature at which its vapour pressure equals to 1 atmosphere.

iii) Density:
mass per unit volume (kg/m³)

iv) Specific Gravity (S)

$$S = \frac{\gamma_{mat}}{\gamma_{wat}} \quad \text{Unit weight } (\gamma) = \frac{w}{v} = \frac{mg}{v}$$

$$\gamma = \rho g$$

v) Opacity:
The property of material that doesnot allow light to pass through it.

vi) porosity $(\eta) = \frac{\text{Volume of voids}}{\text{Total volume}} = \frac{V_v}{V}$
(Volume of material occupied by pore)

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vii) Water absorption capacity:
water absorption capacity is its ability to absorb and retain water. This property is important in case of stones, bricks etc.

viii) Permeability:
It is defined as the capacity of a material to permit water to pass through it under pressure.

b) Chemical Properties:
chemical property of a material is necessary because most of the engineering materials when they come into contact with other substances with which they can react or tend to suffer from the chemical deforation.

i) Chemical Compositron:
This means what is the composition of the material or what are chemrcal substance used while preparing civil engrneering material. so, we should knbw how these chemical substance reacts with other substances.

ii) Corrosion Resistance:-
It is the ability of material to resist corrosion.

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c) Thermal properties:
Important for materials used in structures where there is frequent change in temperature.

i) Specific heat Capacity:-
Amount of heat required to raise the temperature of unit mass of the material by 1°c.

ii) Thermal Conductivity:- Amount of heat transmitted in unit time through unit area over unit length perpn to the direction of heat flow when temperature gradient across heat conducting unit is 1°c.

iii) Linear coefficient of Expansion:-
It is defined as the increase in length per unit length, for each degree rise in temperature.

d) Mechanical properties:-
To determine the load capacity resisting capacity, durability, flexibility.

i) Strength:- Compressive, Tensile, Bending, Torsional, shear
property to resist applied load.

ii) Elasticity:- property of material to regain its original shape and size after removal of load.

Stiffness - resist deformation. $F = KA$, $\Delta = 1, f = k$.

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iii) plasticity:
property to change shape when load is released.

iv) Hardness:-
ability of resistance against wear and tear, abrasion, scratching and cutting.

v) Toughness:- (suddenly applied load માટે resist કરવું)
It is the resistance of material to fracture by bending, twisting, fatigue and impact of load.

vi) Ductility:- can be converted into thin wire
It is that which undergoes large plastic deformation before actual failure.

vii) Malleability:- (can be chyged into thin plate by hammering)
It is the property by virtue of which a material may be hammered or shaped without breaking.

viii) Brittleness:-
- Material breaks easily when subjected to shock due to lack of ductility material.

ix) Resilience:- (elastic limit સમયમા વધારે energy store garyo)
- It is the ability of material to store energy to resist shock.

x) Creep:-
It is the slow plastic deformation of material under constant load for long time.

xi) Fatigue
- Fracture due to repeated load.

e) Electrical Properties:-
The property which shows whether the material can conduct electricity or not is called electrical properties.

i) Resistivity (ρ)
Resist flow of electricity or current. It directly depends upon length of material and cross sectional area. Unit Ωm

$$\rho = \frac{R \cdot A}{l}$$

Copper - low resistivity - 1.7×10^{-8} Ωm
Polythene - high resistivity - 10^{15} Ωm

b) Conductivity (σ)
It is the reciprocal of resistivity. Ability to conduct an electric current.

$$\sigma = \frac{1}{\rho} = \frac{l}{RA} \quad (\Omega^{-1}m^{-1})$$

c) Dielectric Strength:-
Insulating capacity of a material against high voltage. A dielectric is an insulator.

d) Thermoelectricity:-
If two dissimilar metals are joined at its two extremes, placed at temp variation of if conductor is joined at two extremes, it shows flow of small current is called thermoelectricity.

7) Magnetic properties:-

i) Permeability:-
Ratio of flux density in a material to the magnetism force producing that flux density.

ii) Coercive force:-
It is defined as magnetizing force which is necessary to neutralize completely the magnetism in an electromagnet, after the valve of magnetizing force becomes zero.

iii) Magnetic Hysteresis:-
It is defined as lagging of magnetization or induction flux density behind magnetizing force or it is that quality of magnetic substance due to which energy is dissipated in it on reversal of its magnetism.

* Abrasive Resistance:-
Ability of the material to resist wearing due to contact with another surface. When hard rough surface slides across a softer surface, wearing occurs due to which undesired removal of material takes place.

VIP

* Cement grade indicates the compressive strength of cement after 28 days of setting. 43 grade cement attains compressive strength of 43 MPa or 430 Kg/cm² in 28 days of setting.

Cementing Materials:

Cement:- (greenish grey colour)
Calcarious materials ($CaCO_3$)
Argellacious Materials (clay)

(LSACIMSA)

Constituents of cement:- Grade → 28 days strength.

1. Lime (CaO) - 62%
2. Silica (SiO_2) - 22%
3. Alumina (Al_2O_3) - 5%
4. Magnesia (MgO) - 2%
5. Calcium sulphate ($CaSO_4$) - (3-4)%
6. Sulphur trioxide (SO_3) - 1%
7. Iron Oxide (Fe_2O_3) - 3%
8. Alkalies - 1%

IMP

* Bouge Compound:

1. Tricalcium silicate	(C_3S)	($3CaO \cdot SiO_2$)	Alite
2. Dicalcium silicate	(C_2S)	($2CaO \cdot SiO_2$)	Belite
3. Tricalcium aluminate	(C_3A)	($3CaO \cdot Al_2O_3$)	Celite
4. tetracalcium Alumino ferrite	(C_4AlF)	($4CaO Al_2O_3 Fe_2O_3$)	Felite

Alg
48%
25%
10%
10%-

C_3S ⇒ help in early strength (before 28 days)
↳ Rapid hardening cement

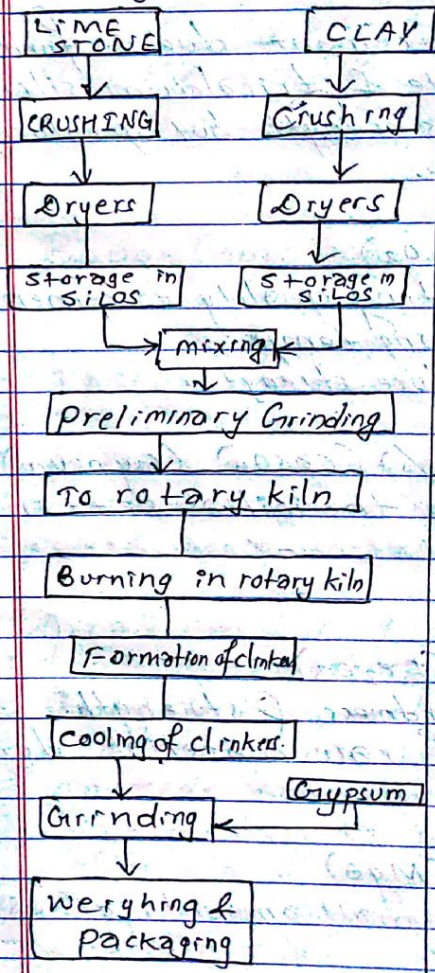
C_2S ⇒ strength after 28 days.
↳ Low heat cement
↳ Slow hardening.

C_3A ⇒ Initial setting
→ High heat generate.
→ if in excess amount - crack.

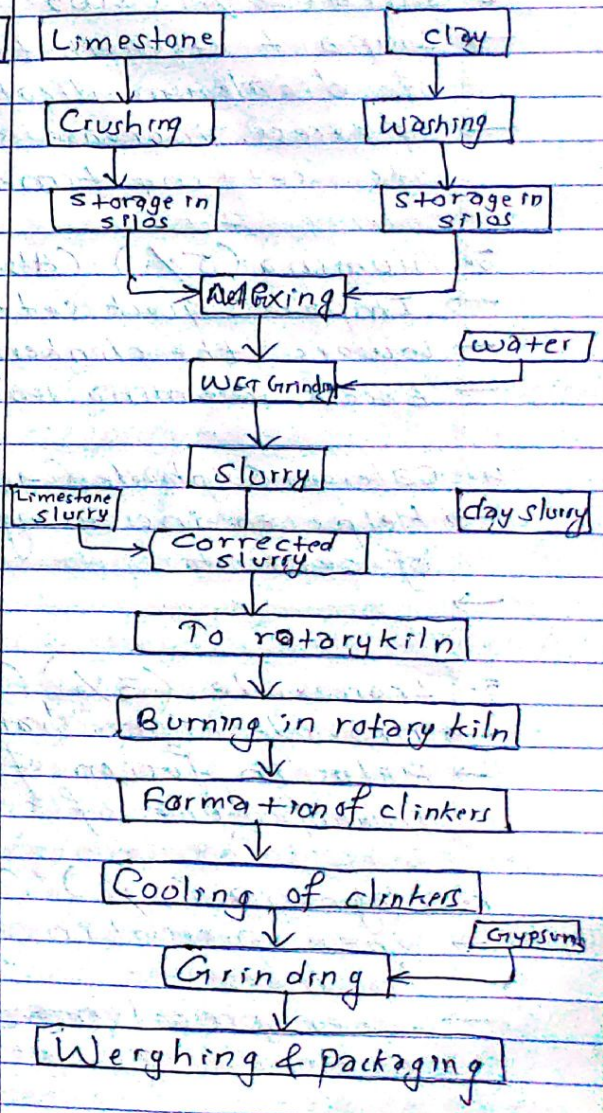
C_4AF ⇒ strength
⇒ poor binding property.

* Manufacturing process of cement

Dry process



wet process



LSACEMSA

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Constituents of cement:-

1. Lime:- (62%) (CaO)
→ make cement sound & strong.
→ If excess, cement becomes unsound & expand
→ If dificient, strength of cement decrease.

2. Silica (22%) (SiO_2)
→ Impart strength to cement due to formation of dicalcium silicate & tricalcium silicate.
→ If excess, increase strength but prolongs its setting time.

3. Alumina (5%) (Al_2O_3)
→ Imparts quick setting quality to cement.
→ Lowers the clinkering temp.
→ Excess alumina reduce strength.

4. Calcium Sulphate (4%) ($CaSO_4$), (Gypsum)
→ Helps in increasing the initial setting time of cement.
→

5. Ironoxide (3%) (Fe_2O_3)
→ provide colour, hardness & strength.
→ Helps in fusion of raw materials during manufacture of cement.

6. Magnesia (2%) (MgO)
→ When present in small amount, gives strength hardness
→ When present in excess, it makes cement unsound.

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7. Sulphur trioxide (SO_3) (1%)
→ If present in small quantity it makes cement sound.
→ If present in excess quantity, it makes cement unsound.

8. Alkalies (1%)
→ should be present in small quantities
→ Alkalis in excess will cause efflorescence.

* Bouge Compound
↳ compositon of cement clinker.

1. Tricalcium Silicate ($3CaO \cdot SiO_2$) (C_3S) 48% (Alite)
⇒ Generates heat more rapidly.
⇒ Hydrates & hardens rapidly.
⇒ Responsible for initial set & early strength.
⇒ posses less resistance to chemical attack.

2. Dicalcium Silicate ($2CaO \cdot SiO_2$) (C_2S) 25% (Belite)
⇒ cement hydrates slowly.
⇒ Generate less heat of hydration
⇒ Hardens more slowly.
⇒ provide good ultimate strength
⇒ Offers more resistance to chemical attack.

3. Tricalcium aluminate ($3CaO \cdot Al_2O_3$) (C_3A) (10%) (celite)
→ cause initial setting of cement.
→ React fast, generating large amount of heat.
→ It is the first compound which reacts with water when cement is mixed with water.

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4) Tetra Calcium Alumina ferrite (C_4AF) (10%) (Felite)

→ Poor cementing value.
→ Comparatively inactive
→ Reacts slowly, generating small amount of heat
→ Doesnot play any significant role on hydration.

* Types of cement:

1) Ordinary portland cement (OPC)
2) Pozzalana portland cement (PPC)
3) Rapid hardening cement (C_3S High)
4) White cement (Absence of iron oxide) (Jointing)
5) Coloured cement
6) Low heat cement (C_2S High, Dam)
7) Blast furnace slag cement
8) Water Repellent cement
9) High alumina cement (No Gypsum)
10) Hydrophobic cement
11) Acid resistance cement

PPC ⇒ 33 grade grade → 22 din N/mm² Compressive

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12) Quick setting cement (small Gypsum)

Sample	dry wt (g)	Wet wt (g)	water absorption (%)
A	1800	2100	16.67%
B	1955	2300	17.64%

The water absorption capacity of both brick A & B is less than 20%. So, according to Indian standard, these brick belongs to first class of brick.

The characteristic of first class brick are as follows.

1) Water absorption is less than 20%
2) Compressive strength - more than 140 kg/cm²
3) Produce metallic ringing sound when two bricks are struck together.
4) colour → eye pleasing red colour.
5) shape: perfectly rectangular with shape right angle sharp edge
6) Size: (240 * 115 * 57) mm
7) Doesnot

Sample	length (mm)	breadth (mm)	P (kg)	Compressive str
A	230	115	20000	75.61 kg/cm² (2nd)
B	224	110	25000	10145 kg/cm² (2nd)

(ball mill / tube mill) → ... → second

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* Manufacture of cement:-

The limestone and clay are grinded separately to fine powders by using grinding (ball mill) mill. Then the powder clay and limestone are stored in silos such that we can use them in required amount. The raw materials are mixed with definite proportions. Then, for dry process, the dry mixture is fed into the rotary kiln and for wet process, the mixture is mixed with water (called slurry) and fed into rotary kiln. In rotary kiln the rxn is divided into three zones.

i) Drying zone:-

The moisture present in raw mixture is dried.

$Al_2O_3 2SiO_2 Fe_2O_3 2H_2O \rightarrow Al_2O_3 + 2SiO_2 + Fe_2O_3 + 2H_2O$

ii) Calcination zone:-

The limestone is decomposed into Quick lime (CaO) with evolution of CO_2.

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

iii) Clinkering zone:-

The temperature is reached about 1500-1600°C in this zone and there is formation of small lumps of 0.15-5cm diameter called clinker by the following rxn

$2CaO + SiO_2 \rightarrow 2CaO SiO_2$

$3CaO + SiO_2 \rightarrow 3CaO SiO_2$

$3CaO + Al_2O_3 \rightarrow 3CaO Al_2O_3$

$4CaO + Al_2O_3 + Fe_2O_3 \rightarrow 4CaO \cdot Al_2O_3 \cdot Fe_2O_3$

Tetracalciumaluminoferrite

In rotary kiln, the temperature reaches to 1300°C and dehydration, vitrification & oxidation takes place simultaneously.

Thus formed clinker is cooled and then grinded by ~~ball mill~~ (tube mill with addition of 3-4% Gypsum to change the setting time of cement. Finally fine ground cement is ~~storag~~ stored in storage tanks from where it is drawn for packing.

* Types of cement:-

1. Ordinary Portland Cement (OPC)
   - → Common type of cement available in market
   - → Medium rate of strength development and heat generation.
   - → Higher resistance against shrinkage & cracking
   - → Less resistance to chemical attack.
   - → Initial setting time:- 30 minute
     Final setting time:- 10 hours
   - → Widely accepted in all types of general concrete construction.
   - → Available in different grades like 33 grade, 43 grade, 53 grade etc.
   - → Used in RCC works for footing, column, beam, slab etc.
   - → Used in building, bridges & roads for flooring, grouting

2. Portland pozzolana cement (PPC)
   - → It is the type of cement in which pozzalanic material such as volcanic ash, fly ash, powdered overburnt brick etc are mixed with clinkers. The pozzalanic material itself has no cementing value but when mixed

with clinker produces cementing property.
→ More resistant to chemical attack.
→ low heat of hydration.
→ Required long period of curing for better strength.
→ It is cheaper than opc.
→ Great resistance to sulphate & corrosive action.
→ produce less heat & higher strength than opc.
→ Attains compressive strength with time but less compressive strength in early days.
→ Imparts plasticity & workability to mortar and concrete prepared from this type of cement.
→ Widely used in hydraulic structures, marine structures, masonary mortar & plaster.

(less than 10% fine) (less finer than ppc) (less curing period) Ordinary Portland cement	less than 5% fineness (more fine) (High curing) Portand pozzolana cement
① When lime & clay mixed with definite proportion & burned, there is formation of clinker which on drying we can get opc.	① When lime & clay mixture is burned, there is formation of clinker on which pozzolanic material is added, there is formation of ppc.
② Less resistance to chemical attack.	② High resistance to chemical attack.
③ High heat of hydration compared to ppc during curing	③ less heat of hydration as compared to opc during curing
④ Early strength is high but final strength is less than ppc.	④ Early strength is low but final strength is greater than opc.
⑤ Higher resistance against shrinkage & cracking	⑤ some less resistance against shrinkage & cracking.
⑥ Expensive than ppc.	⑥ Cheaper than opc.
⑦ used in general construction	⑦ used in structures

3. Rapid Hardening cement:- (RHC)
→ High early strength cement
→ The strength developed at the age of 3 days is same order as the 7 days strength opc.
→ contain higher C_3S.
→ lighter than opc.
→ curing period is short, so it is economical.
→ used in that place where frameworks is to be removed soon.
→ Setting time is same as opc.
→ More heat of hydration, so mostly used in cold areas.

4) High alumina Cement:-
→ Manufactured by fusing the limestone and bauxite at high temperature.
→ chocolate colour.
→ High resistance against fire, acid.
→ Initial setting is greater than opc (about 3 hours) and final setting is 4-5 hours. so, it gains strength in short time.
→ High heat of hydration
→ Costlier than opc.
→ used in under water construction, cold working temperature, chemical plant etc.

5) White Cement:-
→ Same strength as that of opc
→ Greater aesthetic value
→ Clear white in colour due to absenie of iron oxide and magnesia in cement.
→ Oil is used instead of coal during heating to avoid contamination by coal ash.

→ It is manufactured from pure limestone & clay that are free from iron oxide & magnesia.
→ It is expensive.
→ Used in finishing works such as floor finish, the joints, mortar for marble.

* Setting and Hardening of cement:-
→ When cement is mixed with water, a gelatinous mass is formed which remains plastic for short time. The phenomenon by virtue of which the cement loses its plasticity & gradually becomes stiff is known as setting of cement.
→ After setting, the cement binds the aggregates into a solid mass which gains strength as the time lapses, till the hydration is complete. Such phenomena of developing the strength of cement until hydration is called hardening of cement.

* Field test of cement:
① colour should be uniformly greenish grey.
② It should be smooth when rubbed in between fingers.
③ It should feel cool when hand is thrusted into bag.
④ Lumps should be absent.
⑤ A handful of cement thrown in a bucket of water should float.
⑥ Strength: Thick paste is prepared on glass piece & test 7 days in water, the

* Properties of cement:-

1. Physical properties / Test on cement
a) Fineness:-
→ The fineness of cement depends upon its grain size.
→ Smaller the grain, more will be the fineness and vice-versa.
→ Rate of hydration & development of strength depends upon fineness of cement.
→ Finer cement offers greater surface area for hydration and hence the faster will be the strength development.
→ Finer the cement more rapidly it deteriorates on exposure to atmosphere.
→ OPC should have less than 10% fineness & PPC should have less than 5% fineness.

Procedure:-
→ 'W' gm of cement is taken on standard 90 μ IS sieve and if any lumps are present break down with fingers.
→ Continuously sieve the sample giving circular motion about 15 minutes.
→ Weigh the residue left on the sieve. Let 'P' gm be the weight of residue. Then,

$$\% \text{ fineness} = \frac{\text{Weight of residue left on the sieve } (P)}{\text{Weight of cement taken } (W)} \times 100$$

b) Normal Consistency:-

→ This test is performed to determine the percentage of water required for preparing cement paste of standard consistency. The consistency which will permit a vicat plunger having 10mm diameter and 50mm length to penetrate to a depth of 33-35mm from the top of mould. This test is performed by vicats apparatus.

→ 300gm of cement is mixed with 25% of water & paste is filled in mould of vicat apparatus and a surface is labelled. A plunger attached to the plunger is then lowered gently over the cement paste surface & release quickly. The plunger pierce the cement paste. The reading on attached scale is noted. If the penetration is in between 33-35mm from top of mould, the water added is correct.

⇒ Attachments of vicat's plang apparatus:-
i) Square needle:- initial setting time test
ii) plunger needle:- consistency test
iii) Annular Collar → final setting time test.

c) Setting time:-

→ The objective of this test is to determine initial and final setting time of cement.

→ The initial setting time gives the time required for mixing, transportation, placing and compaction of cement mortar or concrete.

→ The final setting time is determined to find that after laying the mortar or concrete, the hardening should be rapid so that the structure may be used as early as possible.

→ The time interval for which the cement products remain in plastic condition is known as setting time.

→ Initial setting time is the time elapsed to start losing its plasticity.

→ Final setting time is the time elapsed to lose plasticity completely.

* 300gm of cement is mixed with 0.85 times water required to give a paste of standard consistency. The paste is filled in mould of vicat's apparatus. Note that, the stopwatch should be started when water is added to the cement. For initial setting, the square needle is attached and gently & quickly release on paste surface. Repeat the procedure until the needle fails to piece a block to a point 5 to 7mm from bottom of mould. Similarly, for final setting time, the annular collor is attached to the apparatus. The cement can be considered as finally

set when the ~~colour~~ mark needle makes an impression on the surface of test block while the attachment fails to do so.

→ The initial setting time is 30 min & final setting time is 10 hour for opc.

d) Soundness:-

→ The objective of soundness test is to know whether the cement concrete undergo large change in volume after setting or not. The unsoundness in cement is due to presence of excess lime and magnesia. The soundness of cement is tested by using "Le Chatelier apparatus".

→ Cement paste is prepared by mixing cement with water of 0.85 times than normal consistency. A cylinder is placed on a glass plate and it is filled with cement paste. It is covered at the top with another glass plate. A small weight is placed on the top. The whole assembly is immersed in water for 24 hours at 24°C to 35°C. At the end, the distance between the indicators is measured. Again the mould is placed on water & boils about 30 minutes after then the mould is removed for one hours. After cooling, the distance between the indicator is measured. The increase in distance represent the expansion of cement. It should be less than 10mm according

e) Specific gravity of cement:-

→ It is the ratio of weight of a given volume of material and weight of equal volume of water. To determine the specific gravity of cement, kerosene is used which doesnot react with cement. Specific gravity is calculated using lechatelier flask.

→ The flask is dried & fill with kerosene. Record level of liquid in flask as V1 ml. put 60gm weighted cement into the flask so that the level of kerosene rises to certain mark, note down the level of flask as V2 ml. then,

$$\text{Specific gravity} = A/B$$

where,

A = weight of cement (gm) / volume of cement.

B = weight of equal volume of water / volume of kerosene.

→ The specific gravity of opc is 3.15.

2. Mechanical properties

$0.195P_n + 7.5$

a) Tensile strength test:-

→ 1:3 mortar with 8% of water content by weight is ~~mixed~~ mixed and moulded into a briquette. The briquettes cured for 24 hours at 25-29°C temp & 90% relative humidity. Average strength of six briquettes tested after 3 and 7 days should not less than 2 N/mm² & 2.5 N/mm² resp.

(Briquette testing machine) 1 hour

ppc specific gravity :- 2.85

$P = \frac{P_n}{4} \times 3.5$

Date _____ Page _____

b) Compressive strength test:-
1:3 cement sand mortar is prepared. Three similar cubes (7 cm side) are prepared & placed in normal atmosphere at about 25-29°C. The cubes are removed from mould after 1 day and cured in water till testing time. 3 cubes are tested in the compression testing machine at 3 days, 7 days and 28 days respectively. For opc, compressive strength at 3 days is ~~350 kg/cm²~~ 23 N/mm², at 7 days ~~330 kg/cm²~~ 33 N/mm² and at 28 days ~~420 kg/cm²~~ 43 N/mm².

In strength test,

$P = \frac{P_n}{4} \times 3.5$

Cement: sand ⇒ 1:3
↓
cubic mould
↑
mortar filled
↓
Check strength using universal compression testing machine
↓
3 days ⇒ 11.5 N/mm²
7 days ⇒ 17.5 N/mm²

Date _____ Page _____

* Lime:-
Lime has been used as a cementing material since time immemorial. In Nepal, upto today, lime has been extensively used for many types of structures. Lime doesn't occur in nature in free state.

→ When calcarious material ($CaCO_3$) is heated, CO_2 & CaO is formed. The CaO is called Lime. Lime is mainly composed of higher percentage of calcium oxide and some percentage of silica and alumina (in the form of clay).

→ The lime formed by decomposition of $CaCO_3$ is quicklime. Quick lime has great affinity for moisture. The process of adding water in sufficient quantity to quick lime is known as slaking

$$CaCO_3 \longrightarrow CaO + CO_2 \uparrow$$
Quick lime

$$CaO + H_2O \longrightarrow Ca(OH)_2$$
Hydrated lime (Slaked lime)

* Types of Lime:-

1. Fat / Rich / pure / White / Quick Lime
→ Having 95% CaO and 5% clay
→ Setting & hardening actions are slow.
→ soluble in water, white colour
→ posses high degree of workability & plasticity.

2. Hydraulic Lime:-
→ Having 70% CaO & 30% clay
→ grayish white in colour.
→ It is set under water in absence of air
→ does not dissolve in water
→ slaking action is slow.
→ Used in under water construction.

Depending on content of silica & alumina it is further divided to three classes
① Feebly hydraulic lime ⇒ less than 15% clay
② Moderately hydraulic lime ⇒ 15-25% clay
③ Eminently Hydraulic lime ⇒ 25-30% clay

3. Poor lime:-
→ contain more than 30% clay.
→ Slaking action is very slow
→ poor binding property
→ sets & harden slowly
→ Used for inferior type of work.

* Propertres of Lime:-
→ Easily workable
→ provides strength to the masonary
→ possess good plasticity
→ offers good resistant to moisture
→ stiffens early
→ provides low shrinkage.

* Uses of lime:-
→ Mortar, plastering works in wall & ceiling
→ For manufacture of cement
→ Fixing wall, floor tiles & other journey works
→ Used as flux in manufacture of steel.
→ Used in manufacture of paint.
→ Used in stabilizing of soil.
→ Used as lining in furnace.

Difference beth Fat lime & hydraulic lime.

Fat lime	Hydraulic lime
1. Contains 95% limestone and 5% clay mineral.	1. Contains from 70% limestone & 30% clay.
2. Milky white in colour	2. Grayish white in color.
3. Slaking action is fast.	3. Slaking actron is slow.
4. It sets in the presence of air	4. It sets in the absence of air under water.
5. Setting & hardening action is slow.	5. Setting & hardening action is fast.
6. produce hissing sound.	6. does not produce hissing sound.
7. Shrinks a lot on drying.	7. Shrinks less on drying
8. Used for white washing, lime plastering, lime mortar etc.	8. Used for lime concrete work under water.
dissolve in water	does not dissolve in water.

(ESFMk)

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※ Indian Standard classification of lime

1. Class A: Eminently hydraulic lime
   Used for structural purposes.

2. class B:- Semihydraulic lime
   Used for masonary mortars

3. class C :- Fat lime
   Used for finishing coat of plastering whitewashing etc with addition of pozzalanic material for masonary mortar

4. class D: Magnesium lime
   Used for finishing coat in plastering whitewashing

5. Class E: kankar lime
   - used for masonary mortars.

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※ Mortar

⇒ Mixture of binding material & fine aggregates.
⇒ Mortar are usually named according to binding materials - used in their preparation

Cement + sand + water ⇒ Cement mortar
Lime + sand + water ⇒ Lime mortar
Surkhi + sand + water ⇒ Surkhi mortar.

→ Mortar is used as binding material in stone or brick masonry, or concrete, as a covering material to walls in the form of plaster to provide a smooth, hard & decorative surface
→ Mortar forms an excellent, even bed for irregular surface of stone & this results in equal distribution of pressure over it.

* Functions of Mortar:- (Use in grouting)

→ Binds together stone or bricks properly so, provide strength to the structure.
→ In stone masonry & brick masonry, it fills up empty joints a thin liquid mortar used for such purposes is termed as grout.
→ In any concrete, it holds coarse aggregates together.
→ Form a homogeneous mass of structure - may resist all loads over it & transform uniformly.
→ provides a durable / weather resisting layer between different courses of masonry in the structure.

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* Types of mortar
  - ↳ cement mortar
  - ↳ Lime mortar
  - ↳ Mud mortar
  - ↳ Gauged mortar

1. Mud Mortar
→ very cheap
→ ingredient are locally available
→ The life of mud mortar surfaces varies from 5 to 15 years depending on its water proofing treatment & weather conditions.

2. Lime Mortar:
→ prepared by mixing lime & sand in the ratio of 1:2 or 1:3 by volume.
→ Light colour
Types
  - ↳ Hydraulic lime mortar
  - ↳ Non-hydraulic lime mortar
  - ↳ Black mortars.

3. Cement Mortars
→ Cement is used as binding material & sand is used as fine aggregate.
→ strongest type of mortar
→ Used in construction structures subjected to heavy loading
→ Cement: sand → 1:3
→ provide waterproof layer & protect from weathering

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4. Gauged mortar:
→ Lime-cement mortar
→ prepared by mixing lime and cement in suitable proportions.
→ Addition of cement increases the hydraulicity (Cability to set under water) & the strength.
→ The process of adding cement is known as gauging.
→ Used for thick brick walls.
→ such mortar are more plastic & workable.

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Mechanical behaviour:-

Normal stress = F/A.

$$\text{Strain} = \frac{\text{change in dimension}}{\text{original dimension}}$$

$$\Delta L = \frac{FL}{AE}$$

$$\text{poisson's ratio } (\mu) = \frac{\text{Lateral strain}}{\text{Long. strain}}$$

Determine the young's modulus & poisson's ratio of a metallic bar of length of 50 cm, breadth 6 cm & depth 6 cm. when the bar is subjected to axial tensile load of 500 kN. The increase in length is given as 0.09 cm & decrease in breadth is 0.005 cm.

⇒ Given,

$L = 0.5\,m$

$b = 0.06\,m$

$F = 500 \times 10^3\,N$

$\Delta L = 0.0009\,m$

$\Delta b = 0.00005\,m$

$$\text{Lateral strain} = \frac{\Delta L}{L} = \frac{0.0009}{0.5}$$

$$\text{Longitudinal strain} = \frac{\Delta b}{b} = \frac{0.00005}{0.06}$$

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$$\text{poisson's ratio } (\mu) = \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$$

$$= \frac{\frac{0.00009}{0.06} \times \frac{0.5}{0.0009}}{}$$

$$= 0.46$$

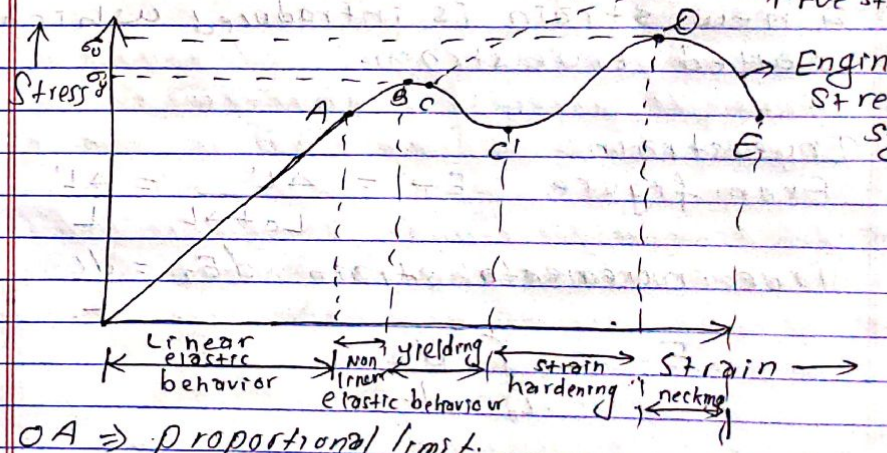
$$\Delta L = \frac{FL}{AE}$$

$$0.0009 = \frac{500 \times 10^3 \times 0.5}{(0.06 \times 0.06) \times E}$$

$$E = 7.71 \times 10^{10}\ N/m^2$$

Stress-strain relationship of ductile Material

True stress strain curve



OA ⇒ proportional limit.

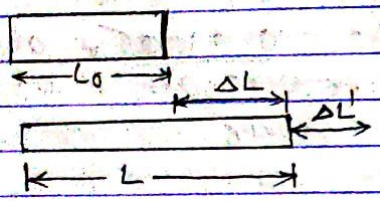
OB ⇒ Elastic limit C ⇒ Upper yield point.

C' ⇒ Lower yield point

D ⇒ ultimate stress

E = Breaking stress.

✱ Engineering strain and True strain



Engineering strain $(E_e) = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}$

When Length is increased by $\Delta L'$, engineering strain is, $E_e = \frac{\Delta L'}{L_0}$

Here L_0 is not original length. L is original length. So, to calculate exact strain a new strain is introduced which is called true strain.

True strain:

From figure, $E_T = \frac{\Delta L'}{L_0 + \Delta L} = \frac{\Delta L'}{L}$

True incremental strain $dE_T = \frac{dL}{L}$

$$E_T = \int_{L_0}^{L} \frac{dL}{L}$$

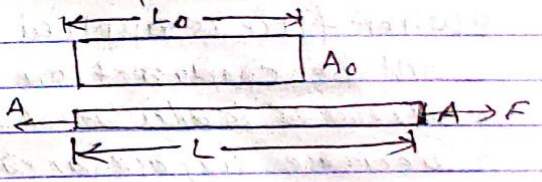
$$E_T = [\ln L]_{L_0}^{L}$$

$$E_T = \ln L/L_0$$

For relationship beth E_e & E_T,

$$E_T = \ln\left(\frac{L_0 + \Delta L}{L_0}\right) = \ln\left(1 + \frac{\Delta L}{L_0}\right)$$

✱ Engineering Stress & True stress



Engineering stress,

$\sigma_e = \frac{F}{A_0}$ $\quad V = 0$

In second case,

$$\sigma_e = \frac{F}{A_0}$$

The force F is not acting on original area A_0 but acting on area A. So, in this sense, the engineering stress is not true representation of the stress.

True stress $(\sigma_T) = \frac{F}{A}$ → current area

Now,

$$\sigma_T = \frac{F}{A_0} \times \frac{A_0}{A}$$

$$\Rightarrow \sigma_T = \sigma_e \times \frac{A_0}{A}$$

But, the volume is constant.

So, $A_0 L_0 = AL$

$$\frac{A_0}{A} = \frac{L}{L_0}$$

$$\Rightarrow \sigma_T = \sigma_e \left(\frac{L}{L_0}\right) = \sigma_e \left(\frac{L_0 + \Delta L}{L_0}\right)$$

$$\Rightarrow \sigma_T = \sigma_e (1 + \Delta L/L_0)$$

$$\Rightarrow \sigma_T = \sigma_e (1 + E_e)$$

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* True stress & strain:-
When force is applied in one direction, there will be contraction in perpⁿ dirn. If the stress is calculated by considering the decrease surface area, such stress is called true stress.

$$\text{True stress} = \frac{\text{Force}}{A - dA}$$

If the strain is calculated by considering final length, the strain is called true strain

$$\text{True strain} = \frac{dL}{L + dL}$$

* Stress strain Curve for ductile material

① OA is proportional limit, straight line, stress is directly proportional strain, obeys Hook's & have linear elastic behaviour

② AB is elastic limit, on further loading the linear relationship break down & material undergo non-linear behaviour. when the material is unloaded it undergo original shape

③ point c is called upper yielding point at which the strain is increased without increase in stress. From point c, plastic region starts

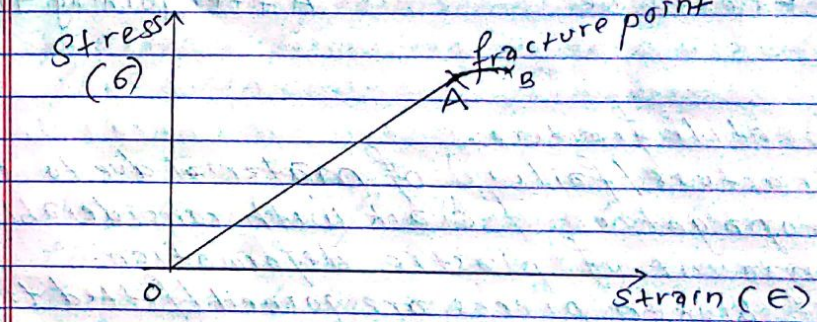
④ After yielding starts, there is drop of load at point c'. The point c' is called lower yielding point.

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⑤ After large deformation, the materials begins to strain hardening. The strain & stress undergoes on increasing & gets peak value is called ultimate stress.

⑥ On further stretching the bar, the load fall from maximum until the fracture at E takes pla The point E is termed as fracture point or breaking point & corresponding stress is called breaking stress.

* Stress-Strain Curve for Brittle material:-



→ OA is proportional limit, stress & strain
→ A to B strain & stress both increases
→ Brittle material develop internal cracks first and then the crack reaches the surface
→ Break suddenly without warning before actual failure.
→ This failure is within elastic limit.

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✻ Ductile and Brittle fracture

(1) Brittle fracture:-

→ Brittle fracture is the failure of material with no plastic deformation (i.e within elastic limit)

→ If the broken preces are fitted together, the orrginal shape is restored.

→ It is low energy fracture. (Area under the curve gives the energy)



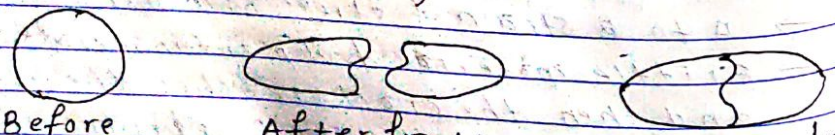
Fracture → After joining fracture

(2) Ductile fracture:-

→ Fracture/failure of material due to slow propagation of crack with considerable amount of plastic deformation.

→ If broken preces are joined/fitted together orrginal shape is not obtained.

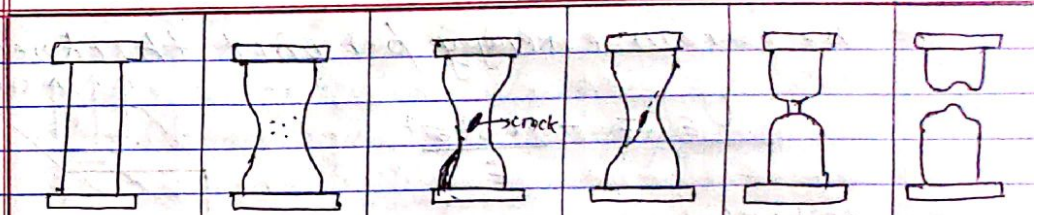
→ It is high energy fracture.



Before fracture → After fracture → joining broken pieces

→ The process involved in ductile fracture mechanism are,

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Unloaded Specimen	start of neck formation	Formation of microcracks	Elongation of crack	End of neck formation	cup-cone formation Fracture.

→ When axial load is applied to the specimen, the neck formation starts with small microcracks.

→ These microcracks propagate & elongate outward to the surface.

→ When load is further increased, there is end of neck formation and large plastic deformation take place & specimen fail with cup-cone formation.

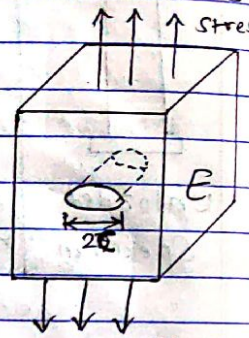
✻ Mechanism of Brittle fracture: Griffith's theory:-

→ According to him, the brittle material contains number of cracks which produces a strain concentration of sufficient magnitude when the crack is propagate, the surface energy is increased. The surface energy requrred for crack extension is equal to the elastic energy released by extending a crack.

Let us consider a crack model. The thickness of plate is negligible. The cracks are assumed to have elliptical shape.

The strain energy per unit thickness

$$U_E = -\frac{\pi c^2 \sigma^2}{E}$$



where,
σ = stress required to propagate the crack in a brittle material
2c = crack length
E = Young's modulus of elasticity

The surface energy due to crack is,

$$U_S = 4c\gamma_s$$

Total change in potential energy is,

$$\Delta U = U_E + U_S$$

$$\Delta U = -\frac{\pi c^2 \sigma^2}{E} + 4c\gamma_s$$

Now, for maxm energy,

$$\frac{d}{dc}(\Delta U) = 0$$

$$\Rightarrow -\frac{2\pi c \sigma^2}{E} + 4\gamma_s = 0$$

$$\Rightarrow 2\cancel{4}\gamma_s = \frac{2\pi c \sigma^2}{E}$$

$$\Rightarrow \sigma = \sqrt{\frac{2\gamma_s E}{\pi c}}$$

This eqn gives the stress required to propagate the crack in brittle material.

Impact strength & its test (Charpy & Izod).

→ Impact strength of a material is its ability to absorb shock and impact energy without failure.

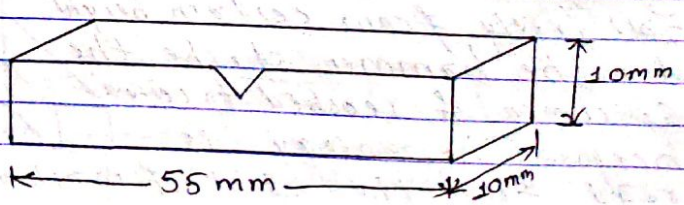
→ The impact test is performed to determine the toughness of material.

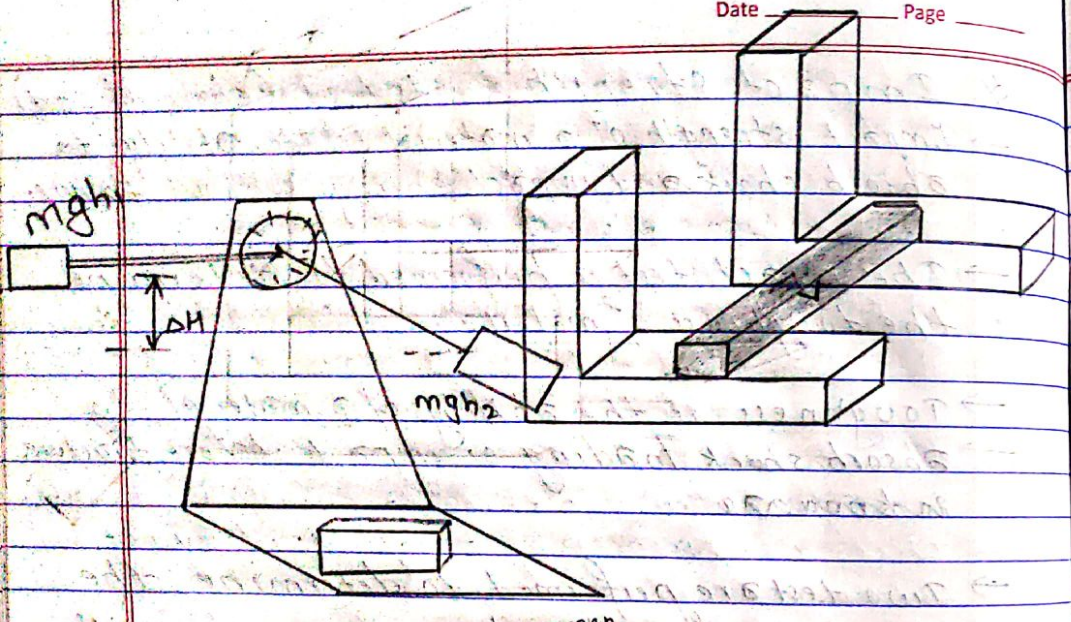
→ Toughness is the ability of a material to absorb shock loading or impact before fracture.

→ Two test are performed to determine the toughness of material.
- ↳ charpy impact test
- ↳ Izod impact test

1. Charpy impact test.

In charpy impact test, the test piece is cantilever, clamped in horizontal position, with 'V' shape notch. The test piece is hit by a striker carried on a pendulum which is allowed to fall freely from a fixed height, to give a blow of 120 ft lb energy. After fracturing the test piece, the height to which the pendulum rises is recorded by pointer on the dial from which the absorbed energy amount is read.





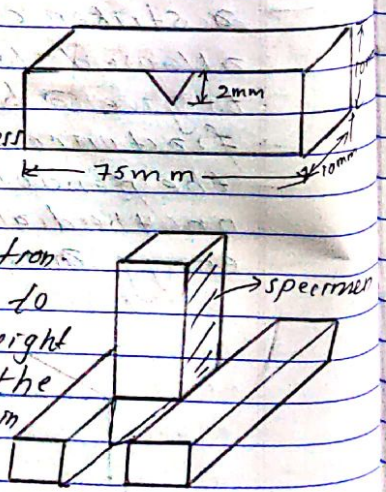
In charpy test, specimen is kept in horizontal position as shown in figure. The energy absorbed by the specimen is,

$$E = mgh_1 - mgh_2$$

$$E = mg\Delta H$$

2. Izod Impact test:-

The objective of this test is to determine the toughness of the material. In this test, the specimen is placed in vertical position. The hammer is allowed to fall freely from certain height & the hammer strike the specimen & reached to certain height. The energy is read from the dial of machine.



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* Hardness types: (~~penetrative~~ Scratch, rebound & indentation) and its test (Brinnel & rockwell)

→

1) Scratch hardness:-

It is determined by scratching the material by finger, knife or minerals. ~~The material~~ If there is no any scratch in the material, the material is said to be hard.

Eg:- Moh's scale of hardness used in mineralogy

3) Indentation hardness:-

It is the ability / It measures the ability of material to resist deformation due to constant compression load from sharp object.

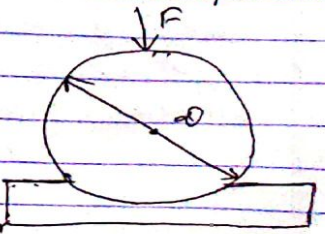
3) Rebound Hardness:-

It can be determined by measuring the height of bounce of a diamond tipped hammer dropped from a fixed height onto a object/specimen.

* Hardness test:-

1) Brinell Hardness Test:-

Brinell hardness is determined by forcing a hard steel ball of specified drameter under a specified load into the surface of material.



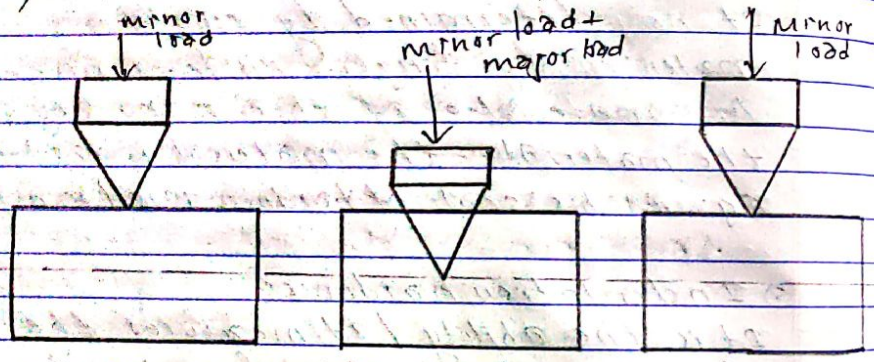
$$BHN = \frac{2F}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

where, D = Indentor diameter.
d = Indentation drameter
F = Applied force

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2) Rockwell Hardness Test:-

The rockwell hardness is determined by measure the net increase in depth of impression as a load is applied.



In this test, diamond core as a penetrator, ball is used. The specimen is placed on table is penetrator is seated by applying loads. The dial gauge reading in dial is made zero & Major load is applied. When the load is removed, the penetration recovered is noted in dial gauge. Less the penetration, material will be hard & more the penetration material will be soft.

TIMBER:-

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→ Timber is obtained from trees. Wood includes all types of wood such as burning wood, structural wood, furniture wood etc. But the wood suitable for use in structure is called timber.

→ Types of timber

* standing timber :- timber available in living tree
* Green timber :- freshly felled tree (more sap)
* Converted timber :- Market size (desired size) (beam, batten)
* Dressed timber :- sawn, placed & worked to exact reqm
* structural timber :- Used in load bearing structure.
* cleared timber : free from defect

※ Characteristic of Good timber:-

→ uniform colour
→ cut surface should give sweet smell.
→ Regular annual ring
→ straight & compacted fibre
→ clear ringing sound when struck together
→ Relatively heavier
→ free from all types of defects.
→ Well seasoned
→ fire resistive
→ Medullary ray should be hard & compact.
→ posses good property of elasticity.
→ should be durable.
→ High strength (strong).

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* Advantages of timber:-

→ Available everywhere & easy to transport
→ Lightweight but high strength.
→ Easy to planed & handle.
→ Simple forming
→ Repair & Modification is easy
→ Good insulator of heat & sound.
→ stands shocks & impacts.
→ corrosion resistance excellent.
→ cheaper than other material.
→ preferred for building works in earthquake regions.

* Disadvantage of timber:

→ Defects in timber can reduce the life of wood.
→ Affected by relative humidity, fungi, insects
→ Transportation & carriage access.
→ Decay of timber when exposed to excessive moisture.
→ Timber has less resistant to fire than other construction material.

* Uses:

→ piles, posts, beams, door, window frame, bridge, poles etc.
→ Used for making furniture.
→ Used in scaffolding, shuttering action
→ Used for manufacturing veneers, plywoods, boards etc.
→ Marine structure due to less corrosion
→ Building work in earthquake region.

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* Classification of trees:-

1. Exogenous trees
→ grow outward with formation of successive annual rings.
→ The number of annual ring determine the age of tree.
→ The timber obtained from exogenous trees is used for building & engineering purposes.
→ Exogenous tree is further classified as,

i) Conifers / Evergreen trees.
↳ evergreen, needle pointed leaf
↳ soft woods, eg: pine

ii) Deciduous trees:
↳ Leaves fall in autumn season and new one appear in spring seasons.
↳ Hardwoods, closed fibrous grain.
↳ eg: sal, sisham, Teak etc.

2. Endogenous trees:
→ grow inward without annual ring.
→ The steams of these trees are too flexible & so, they arenot suitable for engineering works.
→ They are used for temporarary construction
→ growth longitudinally but less growth in outward direction.

eg: Bamboo, sugercane etc.

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* Growth & structure of Exogenous tree:-

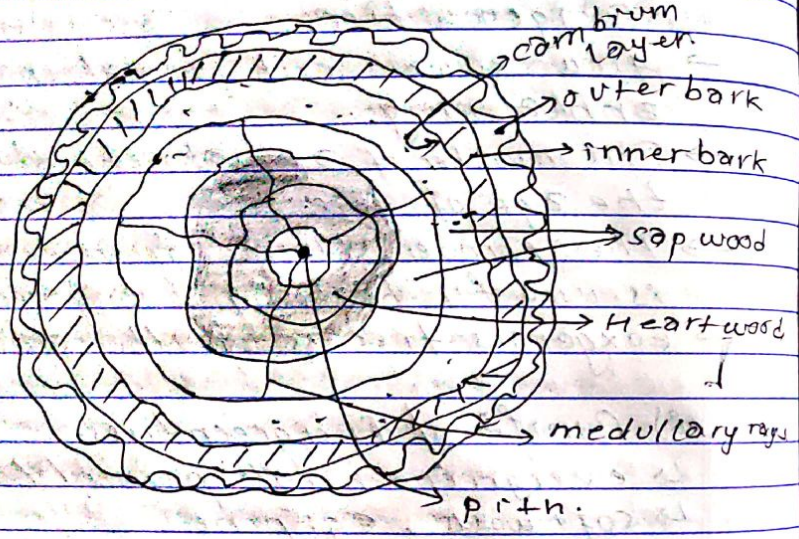


Fig:- Cross-Section of endogenous tree

Basically tree consists of three parts
i) Trunk ii) Crown iii) Roots.

The parts of ~~end~~exogenous tree are

1) pith:-
↳ innermost central portion of tree.
↳ consist cellular tissues & nourishes the plant in young age.

2) Heart wood:-
↳ It consist of inner annual angular ring
↳ compact, strong, durable and darker in colour
↳ dead portion of wood.
↳ provide strength in structure.

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3) Sap wood:-
→ It consist of outer angular ring.
→ light in colour & weight.
→ It helps in growth of tree & contain sap.
→ It carries sap from roots to leaves.

4) Cambrum layer:-
↳ layer betn innerbark & outermost annual ring.
↳ responsible for circumferential growth of tree.
↳ If the bark is removed, the cambrum layer gets exposed and death of tree takes place.

5) Innerbark:-
→ Innerskin or covering of cambium layer.
→ protects cambium layer from injury.

6) Outer bark:-
↳ consists of wood fibre
→ Outermost cover of stem
→ prevent tree from external injuries and weathering.

7) Medullary rays:-
↳ These are thin radial fibres extending from pith to cambrum layer.
↳ Hold annual ring together.
↳ carry sap from outside to inner part of tree.

8) Annual rings:-
→ Cellular wood fibre arranged in circular form concentric circles round the pith.
→ Annual ring are formed in every year.
→ Number of annual ring indicates the age of tree.

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Defects in timber:-

Following are the most common defects in timber

1) knots
2) shakes
3) Rind galls
4) Twisted fibers
5) End splits
6) Druxiness & foxiness.

1) knots:-

→ knots are the defect formed due to formation of annual rings at right angles to surface and also due to twisting of fibres.

→ Reduce aesthetic value
→ disturb homogeneity
→ Decrease strength.



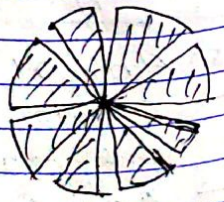
2) shakes:-

→ shakes are nothing just crack. There are many types of shakes

i) Heart shakes:-
→ occur due to shrinkage of heartwood.

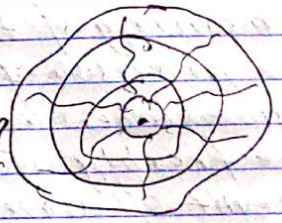


ii) Star shakes:-
→ diminishing towards centre.
→ due to frost action and strong heat of sun.



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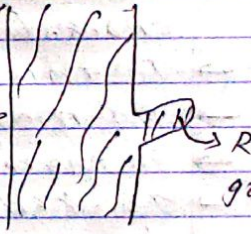
(iii) Radial shakes:-



→ These are the radial cracks extending from centre towards bark.
→ similar to star shakes but are irregular & numerous.

3) Rind Galls:-

↳ abnormal growth of bark.
↳ Rind gall is formed when the branches have been cut off in an irregular & improper manner.



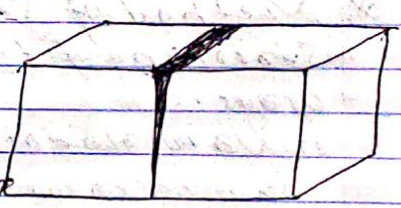
4) Twisted fibres:-

→ Fibres are twisted by velocity of strong wind in one direction.



5) End splits:-

→ Occur at ends of log due to exposed condition during seasoning.



6) Druxiness and foxiness

→ Druxiness is due to attact of cambrium layer by fungus.
→ Foxiness is due to poor ventilation during storage.

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Seasoning of timber:-

→ The process of removing moisture or sap from timber is called seasoning of timber
→ The freshly felled tree contain 50% of weight of water

Objectives of Seasoning:-

→ To minimize the tendency to shrink, warp, crack.
→ To increase strength, durability.
→ To maintain shape & size of component
→ To Make timber safe from defects.
→ To reduce weight for transpose purposes, handling & reduction in cost.
→ Easily workable.
→ Easy to paint, polish & preserve the wood.

Method of Seasoning:-

Seasoning of timber may be carried out in two ways.

1) Natural Seasoning
   - ↳ Air seasoning
   - ↳ Water seasoning
2) Artificial Seasoning
   - ↳ Kiln seasoning
   - ↳ chemical seasoning
   - ↳ Electrical seasoning

* Air seasoning:-

→ Timber is stacked in dry place about 30cm above floor level.
→ Leaving some space betn timber for circulation of air.
→ To protect from direct sunlight, roof covering is used in air seasoning.
→ Required long time.

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* Water Seasoning:-

→ Logs of wood completely immersed in running stream of water. So, that the sap, sugar etc are leached out of the wood and replaced by water
→ quick process

* Kiln Seasoning:-

→ In this process, timber is seasoned under controlled temp & humidity condition with proper control circulation & ventilation System.
→ This process is quick but costly (4-5 days)
→ Require skill Manpower.
→ The temp level should be maintained.

* Chemical Seasoning

→ salt seasoning
→ Timber is immersed in a solution of soluble salt and taken out and seasoned in ordinary way.
→ chances of formation of crack.

* Electrical Seasoning

→ When electricity is passed through freshly felled timber, the heat is generated which helps to remove sap from wood. As a result the wood becomes dry.
→ Required more cost, more electricity, so this method of seasoning is not followed.
→ Employed in plywood manufacturing

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* Preservation of timber:

The art of treating the timber with some chemical so as to protect it & increase its life is known as preservation of timber. The timber can be preserved in following ways.

1) Tarring:-
It is the method of applying a coat of tar.

2) Charring:-
It is done to prevent from attract of insect and fungi in timber.

3) painting
The painting should be carried out through seasoned wood otherwise decay of wood takes place.

4) Fire proofing:-
Fire is highly combustile. A coating of non-combustible material protects the surface of wood from direct contact with large amount of heat.

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* Properties & Uses of bamboo:-

→ Bamboo endogenous trees where annual rings are absent. They growth longitudinally but less growth in outward direction.
→ Bamboo is one of the fastest growing plant on Earth. (Renewable source)
→ It is available easily, everywhere.

properties

→ High tensile strength than steel.
→ Light in weight, easy to transport
→ High wear resistance.
→ Eco-friendly construction material
→ Can bear heavy load.
→ durable, very low water absorption
→ Less seasoning

Uses

→ Building
→ Medicinal purpose.
→ Make clothes
→ Used for scaffolding
→ Used to make furniture
→ Musical instruments.
→ paper
→ structural reinforcement
→ Used in earthquake regions.
→ flooring, walling, ceiling
→ Boards.

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* Wood Based product:-

1. Veneers:-
→ Veneers are the thin sheets of wood of superior quality having thickness varying from 0.4mm to 6mm.
→ Veneers are glued to timber surface to improve appearance and to form decorative & attractive designs.
→ Used in manufacture of plywood, impreg timber, compreg timber, boards etc.

2. plywood:-
→ When two or more veneers are glued together, a composite sheet is formed called plywood.
→ The plywood is generally manufactured in 3ply, 5ply, 7ply & soon.
→ Odd no. of ply are used so that the shrinkage stresses are symmetric about middle ply & warping tendency is minimized.
→ plywood is generally made
i) either by cold pressing
ii) or by hot pressing.
→ Used in covering, panelling walls, for doors, furniture & shuttering RCC works.

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3. Impreg timber
→ The timber which is fully or partly covered with resin is known as impreg timber. The usual resin employed is phenol formaldehyde which is soluble in water. The venners or thin strips of woods are taken and they are immersed in resin. The resin fills the space betn wood cell & by chemical rxn, a consolidated mass develops.
→ Not affected by moisture & weather cond^n
→ strong & durable
→ posses more electrical insulation

4. Compreg timber:-
→ The process of preparing compreg timbers is same as that of impreg timbers except that curing is carried out under pressure.
→ The strength & durability of compreg timbers are more as compared to the impreg timbers.

5. Boards:-
→ formed by joining veeners and strips.
→ There may be following types of board
* Batten board
* Lamin board
* Block board
* fibre board.

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Difference between TMT & TOR:-

TOR	TMT
→ Twisted ore reinforcement steel.	→ Thermomechanically treated bar
→ Cold treated bar	→ Hot treated bar
→ Low strength than TMT	→ High strength than TOR
→ Twisting operation is done while making TOR, so there is residual stress in it.	→ No twisting operation, so, no residual stress.
→ Less ductile	→ More ductile
→ Older type of reinforcing steel.	→ Latest type of reinforcing steel.
→ Less corrosion resistant	→ High corrosion resistant
→ Need weldability & workability	→ Good weldability & workability
→ Manufactured by oldest method.	→ Manufactured by advanced sophisticated technology

Brass

→ alloy of copper & zinc
→ Has higher malleability
→ Low melting point
→ Brass has muted yellow color which is somewhat similar to gold.
→ Excellence corrosion resistant property
→ Strong, tough

Uses

↳ Used as ornament as decoration for gold like bright appearance.
↳ Used for plumbing & electrical application
→ Musical instruments (horn, bells)
→ Used in zippers.

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Aluminium:-

→ Non ferrous metal widely used in civil engineering
→ Aluminium is very abundant in earth's crust.
→ Obtained from bauxite ore.
→ Highly malleable & ductile
→ very light weight.
→ No corrosion
→ Good conductor of heat & electricity
→ very easy to work (High workability)
→ Can be welded & riveted.

Uses:

→ used for making doors, windows frame.
→ Aircraft & automobiles
→ Wires & cables.

Duraluminium (ACMMIS)

→ Alloy of aluminium that contains copper, manganese, Magnesium, iron & silicon & is resistant to corrosion by acids & sea water.
→ Composition:
Al = 95%, Cu = 4%, Mg, Mn, Fe, Si - 0.5% each
→ can be cast, forged & stamped
→ Has high tensile strength
→ Posses high electrical conductance
→ Hardens spontaneously when exposed to room temp.
→ High workability
→ Widely used for sheets, tubes, forging, rivets, nuts, bolts
→ Used in making cables
→ Used for airplanes & other machined where weight is deciding factor.
→ Non-magnetic & other instrument parts.

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Corrosion:-

→ process of gradual attack on metal surface due to the chemical or electrochemical action.
→ Due to such action, metal converted into stable forms of metals like oxides, salts etc.
→ corrosion is reverse process of extracting the metals.
→ While extracting the metal, they are in higher energy state & try to return to lower energy state.
→ Corrosion is undesirable action that reduces the strength of metal, increase brittleness, reduces the aesthetic beauty & working life of metals.

Types of corrosion:-

① Dry corrosion
→ Disintegration of metal surface due to chemical action in ~~presence~~ absence of moisture
→ It is significant mainly at high temperature

② Wet Corrosion
→ Disintegration of metal surface due to chemical action in presence of moisture.
→ It occurs at room tempr.

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Asphalt

→ Mixture of bitumen & inert material (aggregate)
→ It is solid or semisolid sticky product, formed by distillation of certain petroleum oils.
→ Bind strongly as cement.
→ water proof, durable, elastic, ductile
→ It becomes plastic & workable when heated.
→ not affected by adverse weather
→ Soluble in CS_2
→ Used as: dpc, roofs, lining of tank, swimming pools, preparing paint, flooring, pavement etc
→ constituents of asphalt
  * Asphaltenes
  * Resins
  * oils

Types of asphalt.

① Natural Asphalt:-
↳ directly obtained from nature
② Lake asphalt:-
→ obtained from lakes at depths (3-60 m)

③ Rock asphalt:-
→ asphalt found inside limestone rock.

④ Residual asphalt:-
→ Also called artificial asphalt.
→ Obtained by fractional distillation of crude petrolium oils.

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* Bitumen:-

→ Solid or semisolid, black, sticky, ductile substance obtained as an important byproduct from distillation of crude petroleum.
→ It melts or softens on application of heat.
→ soluble in CS_2.
→ Binding material in asphalt.
→ High insulation resistance.
→ Used as dpc, roofs, lining of tanks, swimming pools, water-proof paints, anti-corrosive coatings.

* Forms of bitumen

① Cut back bitumen:-
→ It is obtained by fluxing asphaltic bitumen in the presence of some suitable liquid distillate of coal tar or petroleum.
→ It can be applied cold as bitumen paint.

② plastic bitumen
→ formed from bitumen thinner & suitable inert filler (40-45%)
→ Used for stopping leakage & for filling cracks in masonary structures.

③ Blown bitumen:-
→ It is obtained by passing air under pressure at high temperature.
→ Used as heat insulating material.

④ Straight run bitumen:-
→ It is the bitumen which is being distilled to a definite viscosity or penetration without further treatment.

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⑤ Bitumen Emulsion:-
→ Liquid product containing bitumen in a very finely divided state to a great extent in aqueous medium.

** Tar:-

→ Tar is a black solid mass obtained during the destructive distillation of coal, wood & other material.
→ Tar contains 75-95% of bituminous contents.
→ It contains higher percentage of carbon.
→ It posses toxicity to a high degree.
→ Most adhesive
→ Less resistance to water & acid.
→ Hardens quickly.
→ Becomes more fluid when heated.

Uses
→ Roofing, road making
→ Making bituminous paints & water proofing material
→ coal tar is used for preservation of timber.
→ It is used as saturant for felts.

* Types of Tar:-

① Coal tar:-
→ obtained by destructive distillation of coal.
→ Used for preservation of timber.

② Mineral tar:-
→ obtained by distillation of bituminous shales.

③ Wood tar:-
→ obtained by distillation of pure and resinous tree.

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Gypsum:-

→ $CaSO_4 \cdot 2H_2O$

↔ White crystalline substance.

→ As a binding material, it sets & hardens quickly

→ Gypsum products are good sound absorber

→ They are incombustile

→ Used as filler in paint, paper & rubber industries.

→ Used in manufacturing of cement, plaster of paris.

→ Sparingly soluble in water.

Composite material:-

It is a group of material obtained by combining together materials of different characteristic in such a way that the new material has the best qualities of materials combined together.

Types of Composites.

① metal & alloys

② ceramics

③ polymer

Polymer:-

→ The polymer is formed by polymerization of large number of monomer units.

eg $n(CH_2 = CH_2) \xrightarrow{\text{polymn}} \left(-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\right)_n$

↳ condensation/addition polymer

↳ Natural/artificial polymer.

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Chapter-2 clay products:-

clay:- It is fined grained earth material that is mixture of one or more clay minerals along with traces of metal oxides and organic matter.

Occurence:-

It is abudantly found everywhere on the surface of earth.

Mineralogically a pure clay is composed of one or more clay minerals group such as kaolinite. kaolinite is the most important component of common clays. It is formed from all rocks containing feldspar minerals.

$2kAlSi_3O_8 + 2H_2O + CO_2 \longrightarrow Al_2Si_2O_3(OH)_4 + K_2CO_3 + 4SiO_2$

Feldspar — Carbonic acid — kaolinite — potassium carbonate — silica

Clay products:-

All structural products such as bricks (paving and building), tiles, refractory bricks, terracota, earthenware, stoneware etc that are manufactured using clay is named as clay product.

* Reasons for clay product being popular

i) Easily available and low cost.

ii) Light weight & durable.

iii) Load properts bearing properties is good.

iv) Thermal insulation

v) Aesthetic purpose.

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* Types of clay

1. On the basis of origin
   i) Residual clay
   ii) Transported clay

i) Residual clay:-
These clay are formed from decay of underlying rocks and these clay are pure in chemical composition that is related to parent rock.
Eg: china clay etc.
(Kaolin clay)

ii) Transported clay.
→ These are also known as secondary clays or sedimentary clays.
→ These clays are formed from action of weathering agencies such as wind, rain, glacier etc.
→ These clays are transported to relatively greater distance from the place of origin. Since these are acted by weathering agencies, these clays are finer and more plastic than residual clay.
eg: Lacustrine clay, floodplain clay etc.

2) On the basis of resistance to temperature.
i) Refractory clay - more than 1850°C
ii) High melting clays - (1350-1850)°C
iii) Low melting clays < 1350°C

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* Constituents of brick earth:-
A good quality brick earth should posses a mixture of pure clay and sand for better moulding and dryend to produce brick without shrinking, twisting and warping. It should also contain some propoetion of lime to help clay particles bind together. It should also contain iron oxide to act as coloring agent which provides bright red color to brick.

→ The principal constituents of brick earth are listed as.
i) Silica → 50-60%
ii) Alumina → 20-30% [SALIM]
iii) Lime → 5-6%
iv) Iron oxide → 2-4%
v) Magnesia → < 1%

i) Silica:-
→ It prevents shrinkage, cracking and warping of brick.
→ It also affects the durability of brick.
→ If it is present in excess quantity, it causes to destroy cohesion between the particles and makes brick brittle.

ii) Alumina
→ It is the principal constituent of brick earth.
→ The function of alumina is to impart plastic characteristics to brick earth.
→ If alumina is present in excess quantity it causes shrinkage & warping of brick.

iii) Lime
→ It acts as flux in brick earth and helps the silica in brick earth to melt.
→ It helps to bind the clay particles together.
→ If present in excess quantities, it causes the bricks to melt and change its shape.

iv) Iron oxide
→ Its main function is to provide eye pleasing red color to the brick.
→ Apart from providing red color to the brick it also helps to provide impermeability, durability, strength to the brick.
→ If present in excess quantity it causes to change the color of brick to dark blue or blackish and if present in less quantity causes the brick to change to yellow color.

v) Magnesia
→ The function of this element is to provide yellow tint to the brick.
→ It also helps to prevent shrinkage of the brick on drying.
→ If present in excess quantity it causes decay of the brick.

ALSO

** Harmful Constituents:

a) Iron pyrite:
The presence of it causes crystallization which causes disintegration and cracking of bricks ~~and pebbles~~.

b) Stones and pebbles
→ The presence of stone or pebbles prevents uniform mixing of brick earth.
→ It creates voids and reduces strength of the brick.
→ It also prevents easy working of bricks while using in construction works.

c) Alkalies:
- The excessive presence of alkalies makes the brick earth unusable for manufacturing bricks.
- It acts as flux and causes the brick to change shape.
- On drying the moisture evaporates leaving salty patches on the surface which degrades the appearance of bricks. This process is called efflorescence.

d) Organic Matter
- When organic matter present in the brick earth is burnt it creates voids in the brick thus increasing the water absorption of the brick & reducing the strength.

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* Requirements of good brick earth:-

i) It should contain the principle constituents of brick earth in right proportion.

ii) The constituents particles should be mixed uniformly and have sufficient plasticity

iii) Any harmful matter such as organic matter, waste vegetables, salts etc should be removed from brick earth.

iv) The lime used in brick earth should be free of lumps.

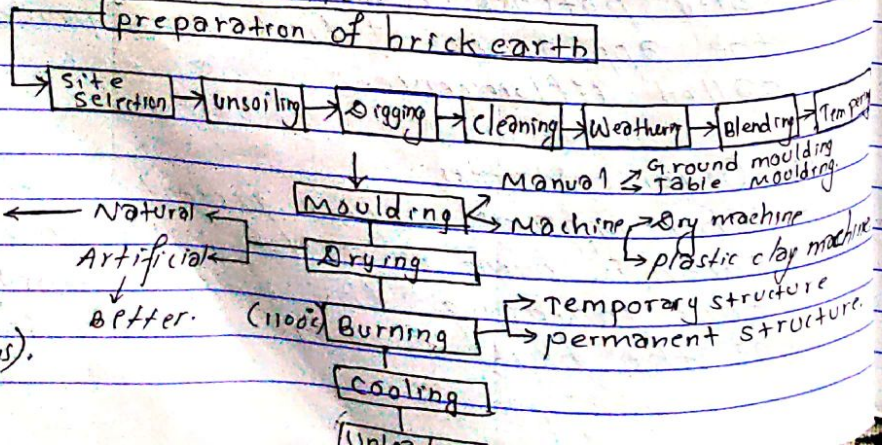
v) The water used in brick earth should be pure without any presence of pollutants.

* Brick:

Dimension 240 × 115 × 57 (mm) (NS)

Mortar joint → 10 mm

* Manufacture of brick:



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* Burning

i) Dehydration (425°c - 750°c)

ii) Oxidation (900°c complete)

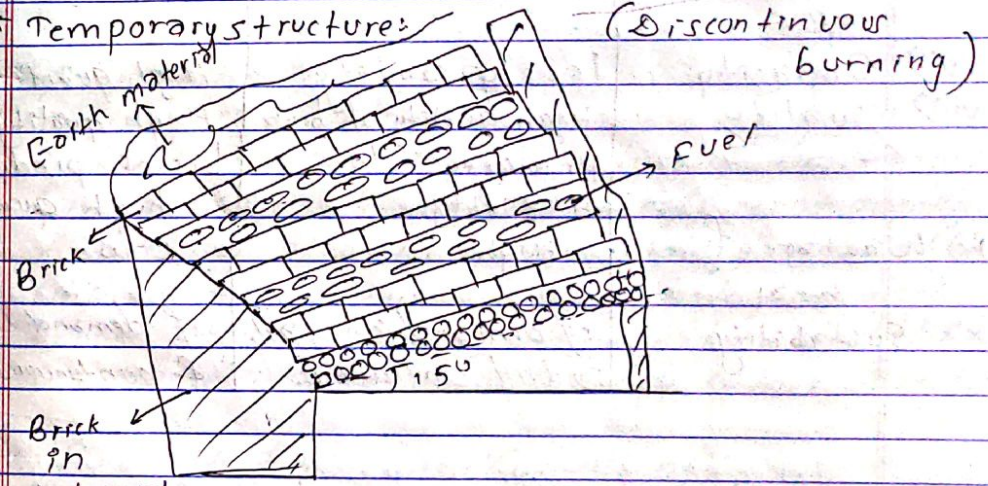
iii) Vitrification :- (1100°c)

→ Temporary structure - eg: clamp

→ permanent structure - continuous kiln

- Semi-continuous kiln

* Temporary structure:- (Discontinuous burning)



* permanent structure:

1. Semi-continuous:
   - intermittent up draught kiln
   - intermittent down draught kiln.

2. Continuous
   - Bull trench's kiln
   - Hoffman's kiln.

Description	clamp	kiln
i) structure	Temporary	permanent
ii) Initial cost	Low cost	High cost required
iii) Supervision	Not required	required
iv) Fuel Cost	Low	High
v) Continuity of operation	Not continuous	continuous
vi) Manufacturing time	4 – 6 month	12-15 days.
vii) Capacity	less quantity	High quantity
viii) Quality	High quality of bricks produced in less quantity	High quality of bricks produced in high quantity
ix) Wastage of heat	High	Low
x) Suitability	If demand is small and not continuous.	If demand is high & continuous

Description	Bull trench's kiln	Hoffman's kiln
i) Nature	Not continuous because it has no roof to operate during monsoon season.	continuous because it can be operated during monsoon season due to presence of roof
ii) Initial cost	Low	High
iii) Fuel cost	High	Low
iv) Drying space	Requires more drying space	Requires less drying space.
v) Burning capacity	less no. of brick than Hoffman kiln.	More no. of brick than trench's kiln.
vi) Suitable	It is suitable when demand is not continuous throughout the year.	Suitable when demand is continuous throughout the year
popularity	More popular because of low initial cost	less popular because of high initial cost.
Quality of bricks.	Percentage of good bricks moderate	Percentage of good bricks high.

* Preparation of brick:- / Manufacture of brick:-

i) Preparation of clay:-

a) Selection of site:-

The site selected for manufacture of brick must have suitable soil available in sufficient quantity. Availability of water, wood, coal, fuel & other important ingredients used while preparing brick play important role in site selection. Otherwise there is unnecessary labour & cost.

ii) Removal of loose soil:- (Unsoiling)

The top layer of loose soil about 20cm depth is taken out & thrown away. The clay in top of soil is full of impurity.

iii) Digging & cleaning:-

The soil below 20cm is dug out & then cleaned off stones, pebbles, vegetable matter etc. All the lumps of soil should be broken into powder form.

iv) Weathering:-

The earth is spread into masses about 60 to 20cm and left for atmospheric action; this process is

known as weathering. It extends from few weeks to some months and imports plasticity and strength to the clay.

v) Blending:-
The process of mixing ingredients is called blending. The whole mass is mixed uniformly and proportionate quantity of water is added.

vi) Tempering
The process of converting brick earth to mud of proper consistency by adding desired quantity of water is known as tempering. It is done either by manual labour or with the help of a mechanical device called pug mill. In manual tempering the clay is kneaded thoroughly under feet of man or cattle to make it stiff & plastic. Water is added gradually & tempering continued till homogeneous mass of earth is obtained. To produce bricks in large quantity, tempering is done with the help of pug mill.

2) Moulding of bricks:-
After preparing clay, we give the proper size & shape by using hand or machine to make brick which is called moulding of bricks. It is of two types
a) Hand moulding
b Machine Moulding.

a) Hand moulding:-
- Moulding is done with hand.
- A wooden rectangular mould made in the shape of brick is normally used for this purpose.

i) Ground moulding:-
- Moulding of brick done on ground.
- places mould in one corner of ground which is already levelled, plastered and sprinkled with sand
- The lift a lumps of prepared clay over his head with both hands, forces it with hands to fill the corner.
- strike superflous clay above the level of mould by prece of wood or iron.

ii) Table moulding:-
- Moulding of bricks on table.
- Initial cost is high but highly economical
- production of better quality & quantity brick compared to ground moulding.

b) Machine Moulding:-
- In this method, the clay is placed in machine, it comes out through the opening under pressure.
- It cuts bricks by steel wires fixed into frames.
- Machine moulding is used where large numbers of bricks are to be made

i) Dry clay machine
ii) plastic clay machine

3. Drying of bricks:-
- After moulding, the bricks are dried for following porpase
→ To prevent from cracking & distortion
→ To remove moisture
→ To save time & fuel during burning
→ To increase strength.
Drying of brick was carried out by two methods.
a) Natural drying b) Artificial drying

a) Natural drying:-
- Wet bricks are arranged in rows on their edges on a slightly raised grains.
- A little space for circulation of air is kept for each brick.

b) Artificial drying
- It is used when bricks are required on large volume & at faster rate.
- The heating of bricks is carried out in special driers such as tunnels or chambers

4. Burning of bricks:-
Bricks after moulded and dried, they are burnt in the kilns. The purpose of burning are as follows.
→ To impart hardness & strength to bricks
→ To increase density of the brick.
→ colour changes into eye pleasing red colour

Types of kiln
1. clamp or open kiln
2. Continuous kiln
3. Intermittent kiln.

1. Clamp burning:-
- In this method alternate layer of air dried bricks and locally available fuel are staked together with 5cm air space bet'n them.
- A slight slope of 15° is usually given to the ground.
- side & top of clamp are insulated by mud.
- takes 2-6 months for burning.
- This method is usually adopted in rural area.
- Supervision & skill labour is not required.

2. Intermittent kilns:-
Intermittent burnt bricks from this kiln is available only after a definite interval of time after it is put on fire. The process of burning of brick is discontinuous. After loading the kiln, it is fired, cooled & unloaded and then the next loading is done

3. Continuous kiln.
When the process of burning bricks is continuous, the kiln is known as continuous kiln. This is the kiln from which it is possible to get the supply of bricks almost continuously. This kiln is continuous in operation. This means that loading, firing, cooling & unloading are carried out simultaneously

It consists of a number of chambers. At any given time, when one chamber in the loading process, another chamber may be in the burning stage, a third chamber in preheating stage, a fourth chamber in cooling stage and fifth chamber in the unloading and supply stage. The continuous kiln are,

i) Bull trench kiln (without roof)
ii) Hoffman's kiln (with roof)

* Qualities of good bricks:
The good qualities of brick is listed below

1) Shape and size:
It should be perfectly rectangular in shape with sharp edges and having specified dimension.

2) Color:
It should have pleasing red colour to view

3) Texture and compactness:
It shouldnot be very rough as well as very smooth and it should be of medium texture. Too smooth texture will cause slipping of mortar while laying brick and also if it is very rough, it takes water from mortar reducing the strength of mortar.
→ Also the brick should be very compact without any voids.

4) Hardness and soundness
→ The brick should be sufficrently hard so that no scratch marks occur while scratching with finger nail and should be sufficiently resistant to abrasion.
→ The brick should produce clear metallic ringing sound when two bricks are stuck together.

5) Water absorption:-
→ The brick should not absorb water more than 25% of its dry weight in any case.

6) Efflorosence:-
→ The bricks should be free from salts which can cause efflorescence degrading the appearance of brick.

7) Resistant to fire
→ The brick should be fire proof.

8) The brick shouldnot be too heavy making it difficult to work.

9) The bricks should have compressive streagth not less than 3.5 N/mm² (140 kg/cm²)

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* classification of bricks:-

1) Unburnt or sundried bricks:
→ The bricks that are not burnt in kiln and only sundried falls under this classification.
→ These bricks cannot withstand load and also should not be used in rainy areas.

2) Burnt bricks:-
→ These are the bricks that are burnt properly upto vitrification temperature i.e 1100°C.
→ Burnt bricks are classified into 4 categories based on Indian classification.

1st class brick
- Water absorption < 20%.
- Strength ≥ 140 kg/cm²
- It is perfect in shape with sharp corners and perfectly right angle.
- It should produce clear metallic ring sound when struck together.
- It has bright red colour
- It should not break when dropped from height of 1m

Uses: It can be used where load is high and these bricks can be used in exterior walls exposed to environment without plastering.

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2nd class brick:-
→ strength 70-140 kg/cm², should not less than 70 kg/cm².
→ water absorption (20-22)%.
→ The color is medium red.
→ This class of bricks also produce clear ringing sound when struck together.
→ The appearance and shape is not perfect like 1st class brick.
→ It should also not breake when dropped from 1m height.
→ Uses
It can be used where load is high but when used in exterior wall plastering work is required.

3rd class brick:-
→ Water absorption greater than 25%.
→ strength (35-70) kg/cm² (not less than 35)
→ It is not perfect in shape with no sharp corners and imperfect right angle.
→ It doesnot produce clear metallic ring sound when struck together and produces dull sound.
→ It has dull red colour.
→ It is easily break when dropped from 1m height.
Uses
It cannot be used where load is high and mostly used in temporary structures.

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4th class of brick:
- It is either overburnt or underburnt brick
- The overburnt brick can have strength higher than first class brick but its shape is highly distorted and hence these bricks are unfit for constructing load bearing structures.

* Quality testing:
i) water absorption test
ii) Compressive strength test
iii) Efflorescence test
iv) Hardness test
v) shape, size and color test
vi) Soundness test
vii) structure test.

(i) Water absorption test:
The brick was dried about 24 hours and dry weight is taken. Then, brick is immersed in water for 24 hours in water. Then, the weight of brick immersed in water is taken.

$$\text{water absorption} = \frac{W_2 - W_1}{W_1} \times 100\%$$

A good brick shouldnot absorb water more than 20% of its dry weight. The bricks should be soaked in water for a minimum of one hour before their use.

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(ii) Compressive Strength Test:
The specimen brick is immersed in water for 24 hours. The frog of the brick is filled with 1:1 mortar and the brick is stored under damp jute bags for 24 hours followed by immersion in clean water for three days. The specimen is then placed between the plates of compression testing machine. Load is applied at a uniform rate and the maximum load at which the specimen fails is noted. Then,

$$\text{Compressive strength} = \frac{\text{Max}^m \text{ load at failure}}{\text{loaded area of brick}}$$

→ The crushing or compressive strength of common brick should not be less than 35 kg/cm². The good quality brick should have compressive strength more than 140 kg/cm².

→ If testing machine is not available, the strength can be determined by dropping a brick from a height of 1m. If the brick does not break when drop from 1m height, then this brick has high compressive strength & suitable for use.

(iii) Efflorescence test:
→ The soluble salts, if present in bricks cause efflorescence on the surface of bricks.
→ In order to find out the presence of soluble salt in a brick, it is immersed in water for 24 hours. It is then taken out and

allowed to dry in shade. The absence of grey or white deposits on its surface indicates absence of soluble salts.
→ If the white deposits cover about 10% surface, the efflorescence is said to be slight and it is considered as moderate when the white deposits cover about 50% of surface.
→ When white/grey deposits cover more than 50% of surface, the efflorescence become heavy and it is considered as serious.

(iv) Hardness test:
This test is conducted by scratching the surface of brick by nail of finger. If no impression is left on the surface, the brick is treated to be sufficiently hard.

(v) Shape, size and Colour:
→ The brick should be perfectly rectangular in shape with right angle, sharp edges.
→ The size of brick should be standard (240mm * 115mm * 57mm).
→ Twenty bricks of standard size are randomly selected and stacked lengthwise along the width and along the height.

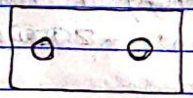
(vi) Soundness test:
→ This test is performed by strucking two bricks.
→ The brick should not break & produce clear ringing sound when strike each other.

(vii) Structure test:-
→ A specimen brick is broken and its structure is examined. It should be homogeneous, compact and free from any defects, eg: lumps, holes etc.

* Stabilized earth bricks:-
They are the environmental friendly unburnt bricks which are made from the clay stabilized with cement or lime. After mixing stabilizing material and clay, it is compressed to make the brick. The bricks are moist cured under polythene sheet in open air. It is cost & energy effective. Consumes less energy than fired bricks. Less polluting than fired bricks.

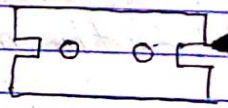
* Types of earth stabilized bricks:-

① Compressed stabilized earth bricks (CSEB)



⇒ Earthquake resistant
⇒ Less quantity cement.

② Interlocking bricks
→ similar to CSEB but there is projection for interlocking.



→ no plastering is required

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✻ Sand Lime Bricks:-

These are bricks made from sand & lime as the raw materials instead of clay.

Sand ⇒ 90%
Lime ⇒ 8-12%
clay ⇒ upto 4%

Preparation:-

- Mixing of sand + Lime + water + clay
- Mould at 300-500 kg/cm² with pressure.
- Left in Autoclaving for drying with high pressure steam about 6-12 hrs.
- In autoclave sand & lime react & form calcium silicate.
- Have high compressive strength.

✻ Fire bricks / Refractory bricks.

These bricks are capable of withstanding very high temperatures without undergoing any deformation. They are used in making inner walls of furnaces. They have low coeff of thmal expansion (1600°C-2000°C heat)

Classification:-

a) Acidic bricks:-
They are resistant to the melts of acidic composition
↳ Fire brick, silica brick.

b) Basic bricks
↳ They are resistant to the melts of basic composition
↳ magnesia bricks, bauxite bricks.

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c) Neutral bricks:-
→ They are non-reactive to both acidic and basic melts.
- Eg: Chromite bricks
- To separate acidic & basic lining.

✻ Concrete blocks:-

→ They are the hollow blocks made from concrete. They are walling materials usually used in non-load bearing walls, partition walls.
→ Size: 125 x 190 x 390 mm (Usually in Nepal)
→ It has speedy construction as compared to brick masonry, which reduces labour cost by 40%.

✻ Tiles:-

→ Tiles are thin slabs of fine brick earth burnt in kiln.
→ As the tiles are thinner than bricks, crack and warpping effect may be more in drying & burning.
→ so, the brick earth used to make tiles should be made pure and carefully prepared.

Preparation
→ preparation of clay
→ Mixing, moulding
→ drying
→ Burning

Date _____ Page _____

* Types of tiles:-

① Wall tile
② Floor tile
③ Drain tile
④ Roof tile

① Wall tiles

→ Burnt comparatively at a low temperature
→ Glazed
→ Used in facework, ceiling, walls

② Floor tiles:-

→ These tiles are flat (usually rect or square)
→ give ringing sound when struck together.
→ The should show maximum resistance to impact.
→ The surface of tile should be clean, dense & sharp at edges.

③ Drain tiles:-

→ When these tiles are laid in the water-logged areas, they allow subsoil water to pass through their skeleton.
→ Drains may be circular, semi-circular.
→ Used for draining waste water.

④ Roof tiles:-

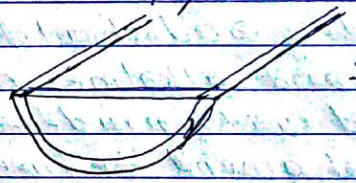
→ These tiles should be strong, durable & perfectly leakproof.
→ They are used for covering the surface of roof.

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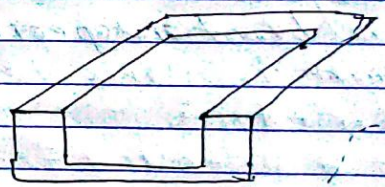
Following are the verity of roof tiles.

1. Flat tiles
   ↳ Rectangular in shape
   ↳ are of various dimensions.

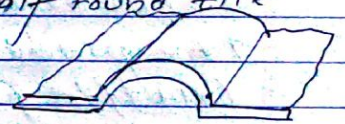
2. Pot tiles:- / Pan tiles
   ⇒ semicircular
   ⇒ used in rular areas.



3. Allahabad tiles:



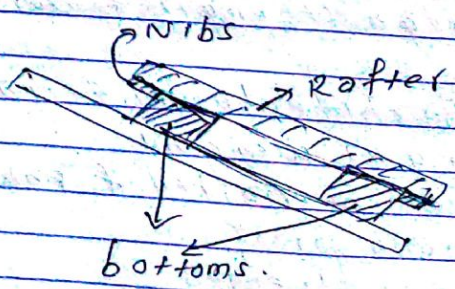
Half round tile



4. Corrugated tiles:



5. Manglore tiles.
(Interlocking)



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Terracota:-

It is an Italian word, Terra means clay and cotta means burnt.
Terracota is refractory clay duct & is used on ornamental parts of buildings.
The clay used for its manufacture should be of superior quality and should have sufficient iron and alkaline matters.
The clay is mixed with powdered glasses, pottery and sand ground to fine powder.
Terracota is impervious, hard and cheap.
The products is burnt in special kilns (muffle furnace).

Composition:-
Dry clay ⇒ 50-60%
Glass ⇒ 8-10%
Crushed pottery ⇒ 20%
Clean white sand ⇒ 10-20%

Classification:-

① Structural terra-cota:-
→ better insulation against heat & sound.
→ Better resistant to wear
→ high strength & durability.

② Architectural terra-cota:-
→ Light weight
→ Can be nailed & sawn to various shapes.
→ sound proof.
→ poor strength
→ used as decorative pieces in building.

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Earthenware:- (Except brick & tile)

→ The clay product which is manufactured from ordinary clay mixed with sand, crushed pottery etc by burning at low temperature is known as earthenware. The earthenwares are soft & porus and may damage by atmospheric action.
→ When glazed, the earthen wares become impervious to the water and they are not affected by acids or atmospheric agencies.
→ Used to make ordinary drain pipes, electric cable conduits.
→ Terracota is high quality earthenware.

Stoneware:-

→ It is the clay product which is manufactured from refractory clay mixed with crushed pottery, powered stone, feldspar etc by burning at high temperature.
→ It is hard, closed grained & durable
→ It is impervious to moisture
→ It can be cleaned easily.
→ It is commonly used as sanitary wares such as wash basin, tubes, sinks drain pipes.
→ It is also used for storage of chemical & food products.

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* Glazing:-
→ It is a protective treatment over the surface of clay products with a view of improving their resistance against water & chemicals & improving their appearance.
→ Glazing is the glassy coat of thickness 0.1 mm to 0.2 mm.
→ Glazing may be transparent like glass or opaque like enamels. Glazing of clay product is done for the following purposes.
- To improve its durability.
- To improve its resistance to water, chemicals & atmospheric gases.
- To improve a pleasing finish and decorative design on its surface.

* Types of glazing:-
(1) Transparent Glazing:-
a) Salt glazing:-
→ NaCl is thrown into kiln containing the article to be glazed at just time of burning.
→ A salt vapourizes forming a thin layer (forms a thin layer of sodium silicate)
b) Lead glazing:-
→ Lead glazing preferred to salt glazing for better articles of better quality.
→ In this method, hot article to be glazed is dipped in a bath containing oxide of lead & tin.
→ Useful for earthenware, terracota etc.

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(2) Opaque glazing:-
→ The glazing materials consists of Quartz, feldspar, boric oxides, Oxide of tin, zinc, lead, china clay etc.
→ A mixture of these materials is prepared and ground to fine paste in presence of water.
→ The clay product to be glazed is first dried & dipped into paste and then fired into the furnace at 120°C.
→ During process of firing, the composition of glaze gets completely vetrified & form uniform glaze of desired color over surface of clay product.
→ Used to make basins, dishes cups etc.

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Metal:-

→ These are elements in perrodic table having 1 to 3 electrons in their valance shell and has the tendency to loose elertrons to achieve stable configuration.

Occurence

Almost all metals are present in fused or mixed form with other impurities and requires Metallurgical process to achieve pure metals. Only some metals like copper, gold, silver are present in free state.

Properties

a) Physical
- Luster
- State (except mercury all are solid)
- Malleability
- Ductility
- Hardness (Na, Li - soft)
- conduction
- density (Lithium ⇒ Lowest density, Iridium ⇒ highest density)
- Melting & bp (Mercury lowest, tungeston-high)

b) Chemical:
A chemical property of metal is its reaction with water & oxygen which results in corrosion.

classification of metal

i) Ferrous Metal:-
The metals having Iron as principle constituent is called ferrous metal.

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eg: pig iron, cast iron, wrought iron

ii) Non-Ferrous Metal:
The metals where iron is not the principle constituent is called Non-Ferrous Metals.
Eg: Copper, aluminium etc.

Alloying:-

Alloy:-

Eg:
Brass, Bronze etc.

Brass: Copper + Zinc — Used for making inexpensive jwellery

Bronze: Copper + Tin — Used for making coins.

Effect of alloying:-

→ Increase in tensile strength
→ Increase depth of penetration for hardening effect
→ Increase fatigue resistance
→ Increase or decrease machineability
→ Improve cutting properties and abrasion resistance
→ Decrease warping & cracking
→ Resistance to corrosion, wear & tear.
→ Improving weldability
→ Decrease the weight.

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✲ Iron:

→ It is the fourth most abundant element found on earth crust. About 6.2% of earth crust is made up of iron.

→ Iron is not found in pure state and is found in mixed form combined with impurities and requires metallurgical process to get pure form.

→ The important ores of Iron are

i) Haematite (Fe_2O_3) (65-75)% iron

ii) Limonite ($Fe_2O_3 \cdot 3H_2O$)

iii) Magnetite (Fe_3O_4) → (70-75)% iron.

iv) Siderite ($FeCO_3$)

v) Iron pyrite (FeS_2)

vi) Copper pyrite ($CuFeS_2$)

Haematite and Magnetite are chief ore.

✲ Types of Iron

i) Pig iron ii) Cast iron iii) Wrought iron

i) Pig iron:

→ It is the most crudest form of iron containing (92-95)% pure iron, (3-4)% carbon and rest are impurities such as sulphur, phosphorous, Magnetite, silicon etc.

→ It is obtained by smelting the ores of iron in blast furnace.

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✲ Properties:-

→ It is hard and brittle in nature

→ It melts easily and its fusion temperature is 1200°C

→ It can be hardened but cannot be tempered.

→ Pig iron cannot be magnetized.

→ Pig iron canot be welded or riveted

→ It is neither malleable nor ductile.

→ It is weak in tension & shear but strong in compression.

✲ Uses:-

→ It is used to produce cast iron & wrought Iron.

→ Pure pig iron is used to produce wrought iron

→ It is suitable to produce base plate, door brackets etc.

✲ Manufacture.

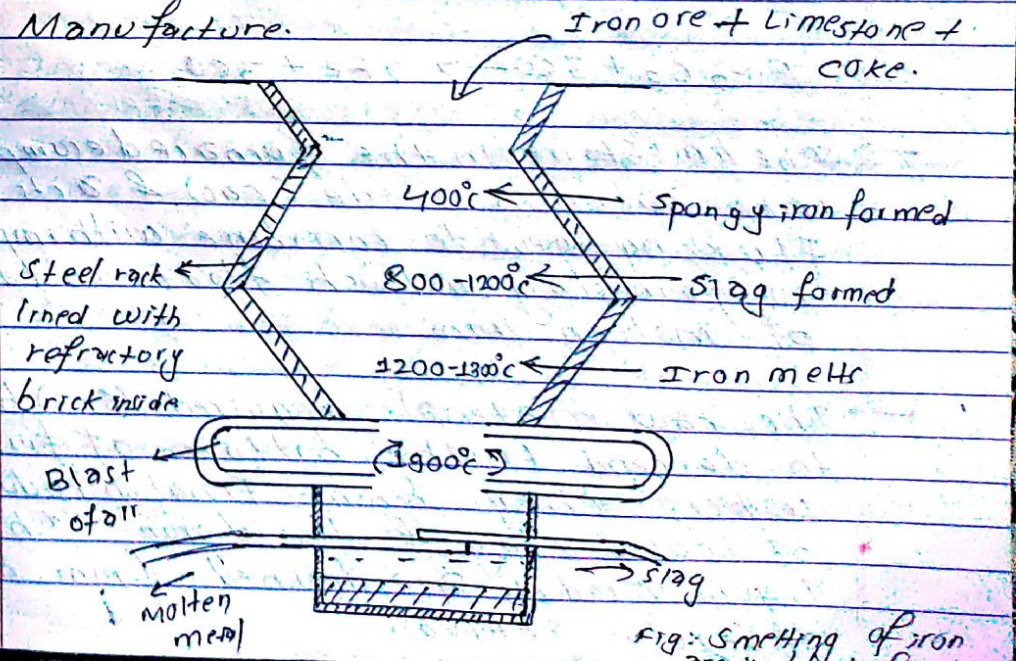


Fig: Smelting of iron

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→ Blast furnace is a type of metallurgical furnace where resmelting of iron ores is carried out to obtain pig iron.
→ It consists of a huge steel rock which is lined with refractory bricks inside where iron ore, limestone & coke is dumped from top. A blast of hot air is provided from the bottom of the furnace with pressure greater than atmospheric pressure.
→ The preheated air burns the coke to provide necessary heat as well as produce carbon monoxide required for reaction to take place in furnace.

$$C + O_2 \rightarrow CO_2 + Heat$$
$$CO_2 + C \rightarrow 2CO$$

CO acts as reducing agent & reacts with iron ore to give Molten iron.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

→ The limestone in the furnace decomposes into calcium oxide (CaO) & acts as fluxing agent to combine with impurities to form slag which floats on top of molten iron.
→ The raw materials required (6-8) hours to descend to the bottom of furnace where they become final product of liquid slag & liquid iron. These liquid products are drained from bottom

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ii) Cast iron :-
→ It contains (2-4)% carbon and contains small amount of impurities such as silicon, sulphur, manganese etc.
→ The amount of carbon present in the cast iron greatly affects the properties of cast iron
→ It reduces cast iron
→ It makes cast iron brittle, non malleable & non ductile.

Uses :-
→ Car parts :- Cylinder, heads, blocks, gearbox cases
→ Pipes, Lids (Manhole covers)
→ Bridges, buildings.
→ Cookwares.
→ Basic material for manufacture of wrought iron & steel.

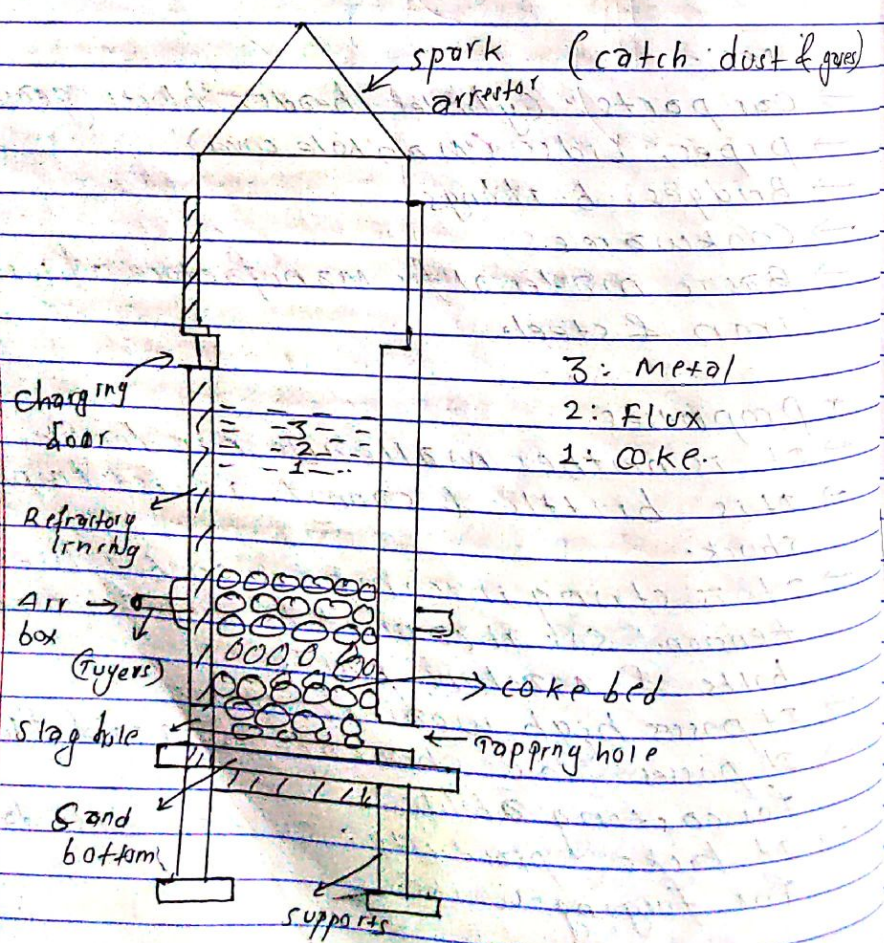
* Properties.
→ It is neither malleable nor ductile.
→ It is brittle & cannot resist impact or shock.
→ It is strong in compression but weak in tension. So, it cannot be used for making bolts & machine parts.
→ It posses high wear resistance.
→ It posses low shrinkage & good fluidity for casting ability.
→ It lacks plasticity. So, it is unsuitable for forging works.

* Manufacture:-

→ The cast iron is obtained by remelting pig iron with coke and limestone in a furnace known as cupola furnace.

→ It is very similar to blast furnace but smaller in size.

→ The diameter of this cylindrical shape furnace varies from 1-2m and height is about (4-5) times diameter.



* Wrought iron:-

→ It is the purest form of iron having carbon content not more than 0.25%.

→ It is purest ~~form~~ iron and is produced by removing most of ~~carbon~~, manganese, silicon, phosphorous and sulphur from pig iron by process of puddling in reverberatory furnace.

* properties

→ It is malleable & ductile

→ It is softer in nature.

→ It can be magnetized.

→ It has high elasticity & tensile strength.

→ It resists corrosion in better way.

→ It can be forged and welded.

→ It has high MP.

Uses

* It is used for making pipes, bolts & nuts due to good corrosion resistance and having better fatigue resistance.

* It is used for making crane hooks

* It is used for making plaster, hand nails etc.

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Manufacture.

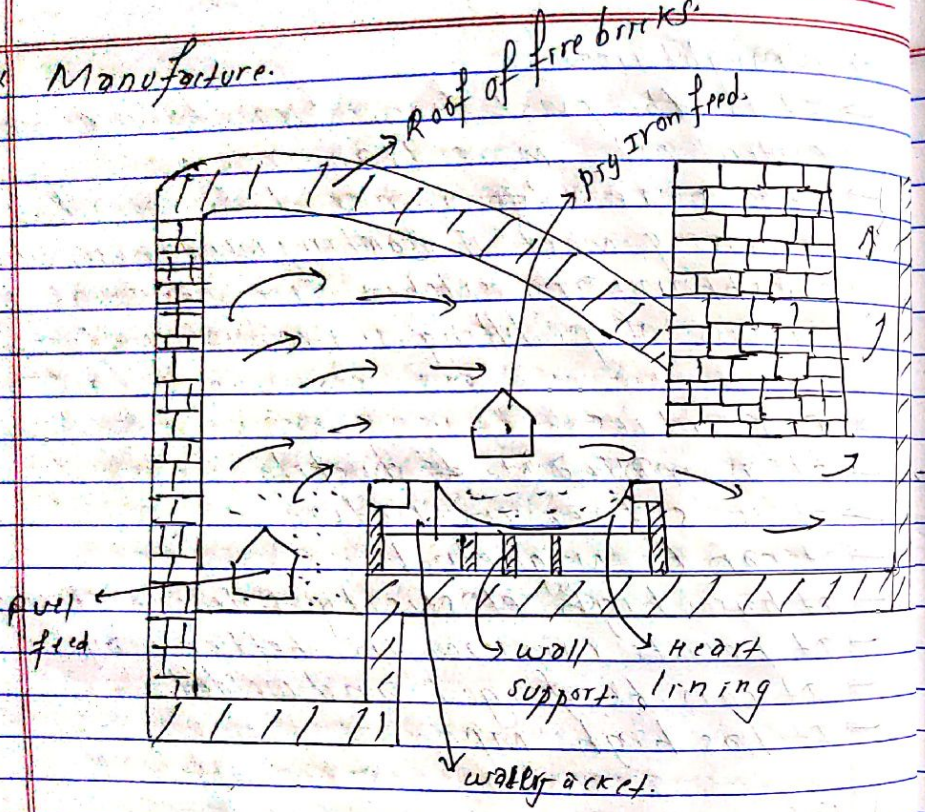


Fig: Reverberatory furnace.

→ Reflectron
→ Metal comes in contact with iron oxide lining, the molten metal is puddle through puddling holes.

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Steel:-

→ Steel is a product containing almost pure Iron and small proportion of carbon ranging from 0.5-1.5%

→ It is manufactured from pigiron by removing impurities like carbon, silicon, phosphorous etc present in the pig iron by oxidation and adding requisite amount of carbon to get desired properties in steel.

Properties.

1) It is highly malleable and ductile.
2) It has good tensile strength & toughness property.
3) It can be hardened & tempered.
4) It has high melting points ranges from 1300 – 1400°C.

Uses

→ It is used as reinforcing bars in construction of various building elements like beam, column, slab, foundation etc.
→ Manufacture of automobile parts.

Classification of steel

① On the basis of carbon content
a) Low carbon steel
b) Medium carbon steel
c) High carbon steel

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(ii) On the basis of types of alloy known as alloy steel.

(i) On the basis of carbon content

a) Low Carbon steel
→ Have proportion of carbon upto 0.25%
→ Most abundant grade of steel.
→ It is not responsive to heat treatment.
→ Has good weldability and machinability.
→ Has got better tensile strength ~~that~~ than cast and wrought iron but has less compressive strength than cast iron.

Uses
→ Used in manufature of structural sections such as girders, reinforcing rod etc.

b) Medium Carbon steel
→ It is stronger in compression as well as tension and is much tougher than mild steel.
→ It is malleable & ductile
→ Tensile strength is better than cast iron & wrought iron.
→ can be permanently magnetized.
→ can be hardened & tempered but not easily

Uses
Used for all kinds of structural works in bridges & building, bolts, wired, tapes.

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c) High Carbon Steel:-
→ Carbon content is 0.8% to 1.5%.
→ It is more tough & elastic than mild steel
→ It is easier to harden and to temper.
→ It is more difficult to forge and weld.
→ It can be permanently magnetized.
→ More strong in compression than tension and shear.
→ It can withstand vibrations and shocks better.

Uses:-
→ Used for making drills, files, chisels, hard part of machines.

✻ Alloy steel:-

(1) Cobalt steel
→ The major component of cobalt steel in high carbon steel and element cobalt.
→ The alloy is used for making cutting tools.

(2) Copper steel:-
→ The major component of copper steel is copper & steel. The amount of copper varies from (0.15-0.25)%
→ This alloy steel has special property of resisting the effect of atmosphere.

③ Manganese steel
→ The major component is manganese & steel, The Manganese increases hardness, toughness and strength of steel.

→ Used in gears, railways, crossing etc.

④ Nickel steel
→ It consists of (3-4)% Nickel in (0.15-0.5)% carbon.
→ Nikel increases the strength of steel by increasing toughness, hardenebility and corrosion resistance.

⑤ Vanadium steel:-
→ It consists of vanadium and steel and used for manufacturing automobile parts and spring components of automobile.

⑥ Stainless steel:-
→ It is structural steel with copper content 0.2% which helps to resist corrosion better than steel without copper
→ protection is due to dense film of oxide formation over the surface of metal.

* Three Groups of Stainless steel:-

① First Group
→ chromium content < 16% and very low carbon content 0.4%
→ used for preparing steam valves, turbine, blades etc.

② Second Group:-
→ Chromium content < 16% and carbon content less than 4%
→ They can be forged, rolled and can be machined to produce special designed tools. It is also used to produce wires and pipes.

③ Third Group:-
→ Chromium content > 24%
→ has good corrasion resistance
→ These variety of steel is tough and its use lies in chemical plants, pump, shaft etc.

* Heat treatment of steel.

Principle

→ ~~Manufacture of steel~~ Microstructure of steel:-
Ferrite → soft and ductile
Cementite → Hard and brittle
pearlite → Combination.

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- lower critical temperature → peralite changes to austentite
- As temp^r increases further & reaches upper critical temperature → ferrite and cementite dissolved in austhentite
- As the upper critical temp^r is hold for some hours (Soaking) → The steel is completely austentite

Austentite:- Ductile steel
Martensite:- Hard steel

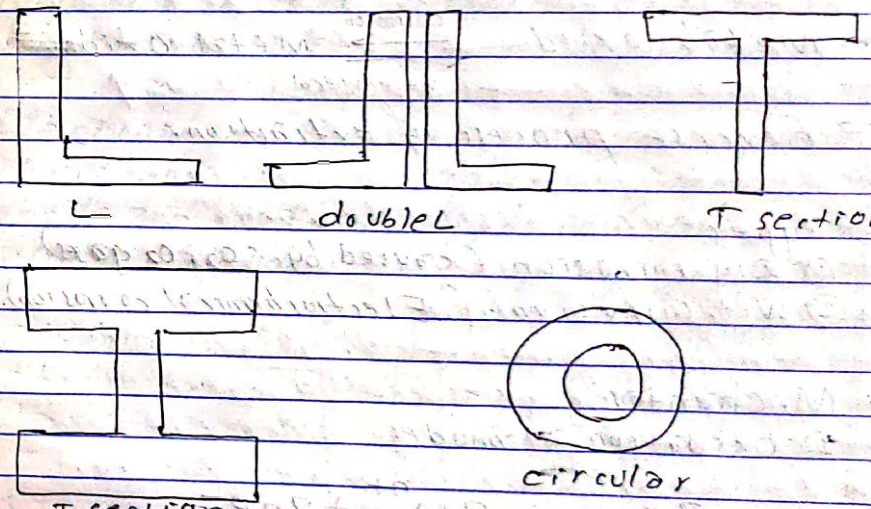
Objectives
→ Mechanical properties modification
→ Crystal rearrange
→ Improve machineability
→ Refine grain
→ To increase
→ To increase/decrease the strength of steel.

* Methods:-
① Annealing - furnace cool
② Normalizing - atm. cool
③ Quenching → fast cool (more hard
④ Case hardening → some part hard
⑤ Tempering :- Hard steel to ductile (but annele & normlu steel) ductile good)

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* Different forms of rolled steel section
- Cross section of rolled steel section depends upon
i) Structural efficiency
ii) Functional required
iii) dimension & weight capacity of rolling mills
iv) material properties

Forms



Hot rolling : rolling above crystallization temp^r
Cold rolling : rolling below " "

* TOR steel & TMT steel

Date _____ Page _____

* Properties, uses & advantage of
→ stainless steel
→ Brass - ornament (Cu+Zn)
→ Tool steel - (hard) - resistance to weathering & abrasion
→ Aluminium - (Light wt, no corrosion). (Aircraft)
→ Duralinium -

* Corrosion of metal & its prevention

Metal → Metal oxide (corrosion ⇌ metallurgical) Metal oxide.

→ Reverse process of extraction.

* Types
① Dry corrosion (caused by SO_2, O_2 gases)
② Wet corrosion. (Electrochemical corrosion).

* Mechanism:
1) Oxidation at anode.

$$2M \longrightarrow 2M^{n+} + 2ne^-$$

2) Reduction at cathode:-
Oxygen is converted to oxide ion due to transfer of electrons from metal

$$\frac{n}{2} O_2 + 2ne^- \longrightarrow nO_2^-$$

$$2M + \frac{n}{2} O_2 \longrightarrow 2M^{n+} + nO_2^-$$

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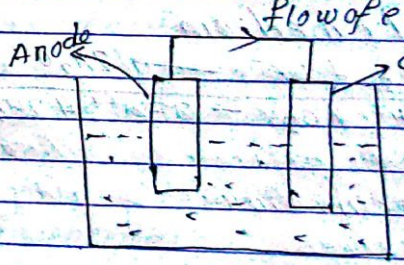
* Metal oxide layer
↳ (a) Stable
(b) Unstable

* Wet Corrosion:-
→ When metal is in contact with conducting liquid.
→ When two dissimilar metals are dipped in solution

* Lower reduction potential acts as anode & higher reduction potential acts as cathode.

* Electrochemical Series determine anode or cathode
The element with low reduction potential acts as anode and that with high reduction potential acts as cathode.

Mechanism



At anode
Oxidation takes place:

$$M \rightarrow M^{n+} + ne^-$$

The metal ions is either dissolved in solution or changed into oxides.

$$Fe \longrightarrow Fe^{2+} + 2e^-$$

At Cathode
1) Evolution of hydrogen
(absence of dissolved oxygen)

* In acidic medium:

$2H^+ + 2e^- \rightarrow H_2 \uparrow$

$Fe + 2H^+ \rightarrow Fe^{++} + H_2 \uparrow$

* In neutral or alkaline medium:

$2H_2O + 2e^- \rightarrow H_2 \uparrow + 2OH^-$

$Fe + 2H_2O \rightarrow Fe^{2+} + 2OH^- + H_2 \uparrow$

$Fe + 2H_2O \rightarrow Fe(OH)_2 + H_2 \uparrow$

ii) In presence of dissolved oxygen

* In acidic medium

$4H^+ + O_2 + 4e^- \rightarrow 2H_2O$

$2Fe + 4H^+ + O_2 \rightarrow 2Fe^{++} + 2H_2O$

* In basic medium:

$2H_2O + O_2 + 4e^- \rightarrow 4OH^-$

$2Fe + 2H_2O + O_2 \rightarrow 2Fe^{2+} + 4OH^-$

$Fe + H_2O + \frac{1}{2}O_2 \rightarrow Fe^{2+} + 2OH^-$

$Fe^{++} + 2OH^- \rightarrow Fe(OH)_2$

* If enough oxygen is present.

$4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$

yellow rust & it corresp
to $Fe_2O_3 \cdot H_2O$ which is

* If supply of oxygen is limited the corrosion may be black (Fe_3O_4)

** Factors affecting corrosion

(1) Primary factor
- Nature of metal
- Surface of metal
- ~~Metal~~ Nature of metal oxide formed

(2) Secondary factor
- pH value
- Temperature
- presence of oxidising agents like halogens, nitric oxide etc
- Humidity
- Conductance of medium
- Area effect
(Smaller anode area & large cathode area ~~increasing~~ increases rate of corrosion.

** prevention of corrosion:-
1. protection by design & fabrication.
2. Modifying the corrosive environment
3. Use of inhibitors
4. cathodic protection
5. Alloying
6. Application of protective coating
   - ↳ enamel painting
   - ↳ Tin plating
   - ↳ galvanizing

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Glass:-

→ Glass is any substance that has solidified from the liquid state without crystallization.
→ Glass may be defined as a hard, brittle, transparent or translucent material chiefly compound of silica.
→ Glass is an amorphous substance having a homogeneous texture.

* Properties:-

→ No definite crystalline structure
→ No sharp melting point
→ Absorbs, refracts or transmits light.
→ Affected by alkalies.
→ An excellent electrical insulator
→ Extremely brittle
→ Available in beautiful colours.
→ Not affected by air and water.
→ Not easily affected by ordinary chemical reagent.
→ Possible to weld pieces of glass by fusion.
→ Easy to clean.

Plastics:-

→ Plastomer formed from ~~Rubber~~ resin.
→ Non-metallic material that can be moulded to desired shape.
→ Types
Thermoplastic — soft on heating
Thermosetting plastic — hard on heating

follow chemistry copy

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Rubber:-

→ Rubber are elastomers which poses elasticity & good resistance to corrosive fluids.
→ Strong & tough
→ Highly impermeable to both water & air.
→ Bad conductor of heat.
→ By vulcanization, the properties of rubber can be improved.

Types
① Natural rubber ② Synthetic Rubber.

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TOR steel	TMT steel
① Twisted Ore reinforced steel.	① Thermo Mechanically treated steel
② It is formed by cold rolling.	② It is formed by the process of hot rolling
③ Less ductile	③ More ductile
④ Case hardening is not done	④ Case hardening is done
⑤ Less strength than TMT.	⑤ More strength than TOR
⑥ Twisting operation is done, so there is residual stress in it.	⑥ No twisting operation so, no residual stress.
⑦ Older type of reinforcing steel	⑦ Latest type of reinforcing steel

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Stone:-

→ Stone is a compact, solid, massive material that makes the crust of earth and obtained from rock.
→ The rock quarried from quarry is called stone.

* Classification of stone:-
i) on the basis of origin
  ↳ Igneous
  ↳ Sedimentary
  ↳ Metamorphic
ii) On the basis of physical form
  ↳ stratified
  ↳ unstratified
  ↳ Foliated.
iii) On the basis of chemical composition
  ↳ Siliceous
  ↳ Argillaceous
  ↳ Calcerous

* Physical classification of stone:-

i) Stratified rock:-
The rocks which show distinct signs of layers and can be easily splitted up into layers
Eg:- Limestone, sandstone (sedimentary)

ii) Unstratified rock:-
→ It is also known as massive rock.
→ doesnot show distinct sign of layers.
→ Cannot be splitted up into layers
Eg:- Granite, basalt etc (Igneous rock)

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iii) Foliated Rocks:-
→ Rocks having foliation plane.
→ Can be splitted up into thin sheets
→ Eg:- slate, schist, garnetoferoschist etc
(Foliated - Metamorphic rock)

* Characteristics of Good Building Stones
→ Should have sufficient compressive strength
→ Must be adequately hard.
→ Must be tough enough.
→ Good stone should have less than 5% water absorption
→ Uniform colour
→ Grains are compact & uniform
→ should be easily & economically dressed.
→ strong & durable.
→ Easy to work.
→ should be able to resist high temperature.
→ should be well seasoned.
→ available easily in low cost.
→ should have high specific gravity (2.4–2.8).

* Quarrying of stone:-
→ The process of extraction of suitable stones from their natural place of occurrence for use in construction is called quarrying.
→ The place from where stone is obtained ⇒ quarry
→ Quarrying differs from mining used for extraction of ore.

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Selection of Quarry Site:-

→ Availability of sound rock
→ The distance of construction side from quarry should be less.
→ Drainage from quarry should be easy
→ Facility for transportation should be available.
→ Quarry side should be far from permanent structures.
→ Sufficient space should be available for installation of crusher, storage of stone etc.
→ Geological information of site should be studied.
→

Methods of Quarrying

1) Digging / Excavating:-
If the stone are buried under earth surface, the stone is extracted by excavating using crowbars, pick-axes, kassi

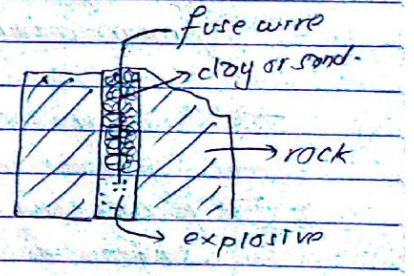
ii) Wedging:-
This method is used for the rocks which are splitted into thin sheets. In this method, the crack is observed first. The steel wedge or points are then driven with the help of hammer. In the way the layer of stone is obtained.

iii) Heating:-
The fud is collected in exposed surface of stone and startfiring so, that expansion place

iv) Channeling Method:-
It involves the use of big machine called channelizers. When large size stone is required, channeling Method is used. A groove is cut around the stone block with the help of this machine. Then, the stone blocks are detached by drilling holes/wedging.

v) Blasting:-
Blasting is the method of quarrying with the help of explosives. This method is used to excavate/extract a hard stone.

process
a) Boring hole in the rock
b) Charging with explosive
c) Tamping
d) Firing.



Dressing of stone:-

→ The process of giving proper shape and size to the stone is called dressing of stone.
→ The stone obtained from quarry is irregular in shape & size and cannot be used in masonary work without dressing.
→ The dressing is carried out either manually or mechanically.

Objectives of Dressing of stones

→ Good apperance
→ Reduce cost of transportation by reducing the size of blocks.

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→ Freshly quarried stones contain some moisture called quarry sap. so, it is easier in dressing of stone.
→ The surface of stone becomes smooth. So, ~~it~~ however less amount of motar is required during laying of stone.
→ Aggregate can be obtained from dressing of stone.

* Seasoning of stone:-
→ The process of removing quarry sap from stone is called seasoning of stone.
→ The good stone should be free from sap.
→ Presence of moisture makes the stone soft & it can be decayed when used in structural work.
→ In seasoning, the stone which are dressed are left for a period of 6 - 12 months for proper seasoning before used in construction work.
→ It makes the stone hard & compact.
→ All the stones should be ~~also~~ seasoned before they are used in construction work.

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* Artificial Stone, Characteristic & Uses:-

→ The stone made by mixing crushing stone prece, cement, water and colouring pigment in right proportion.
→ We can made the size & shape of stone according to our requirement. This is main advantage of artificial stone.

* Characteristics:-
1) More durable than natural stone.
2) The artificial stone can be made at the place of construction. so, cost is not required for dressing & transportation.
3) It can be easily moulded into any shape.
4) Have good compressing & crushing strength.
5) It can be made in single prece and hence trouble of getting large blocks (number) of stone is avoided.
6) very low water absorption.
7) Grooves, cavities & hollows can be provided as desired.

* Uses:-
→ Used as caps of piers
→ Used for paving, for masonary work.
→ Used in irrigation canal
→ Roof covering material
→ Used in bridge, pier construction, building construction

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* Aggregate:-

→ Aggregate is a inert material obtained from rocks & crushed stones.
→ It provide body & strength to the concrete
→ Aggregate occupy 75% volume of concrete & being comparetively cheaper.
→ Beside providing strength, other propertes such as durability, workability, shrinkage, stability are governed by aggregate.

* Classification of aggregate:-

on the basis of size of grain, the aggregate can be classifred as.

a) Coarse b) fine

*) Fine aggregate:-

→ Aggregate having grain size 0.15mm to 4.75mm are known as fine aggregate.
→ Aggregate which passes through 4.75mm IS sreve is fine aggregate.
→ Eg:- sand.

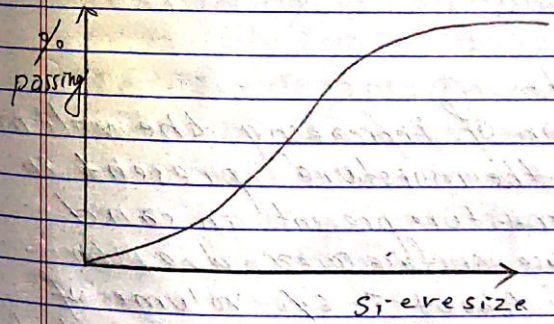
*) Coarse aggregate.

→ Aggregate having grain size 4.75mm to 80mm are known as coarse aggregate
→ They are obtained by natural disintegration of rock.
→ Aggregate retained in 4.75mm IS-sreve is called coarse aggregate.
→ Eg:- Gitti (local name).

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* Gradation of aggregate:-

→ Grading means particle size distribution.
→ The grading determine the amount of cement to be filled in the voids for workable concrete.
→ If only coarse or only fine aggregate are packed, there will be more voids. so, to decrease the void, the coarse & fine aggregate are mixed in proportion which is called gradation of aggregate.
→ Grading of aggregate is analysed through curve called grading curve. To plot this curve sreve analysis is performed.



Seive size	Weight retained	% weight retained	Commulative % retained	Commulative % passing
4.75mm	50	4.16	4.16	95.84
2.36mm	100	8.33	12.49	87.51
1.18mm	110	9.17	21.66	78.34
600 umm	200	16.67	38.33	61.67
300 umm	210	17.5	55.83	44.17
150 umm	250	20.83	76.66	23.34
75 umm	280	23.83	99.99	0.01
	ΣM=1200		ΣR=309.12	

→ The grading of aggregate is done by fineness Modulus method/ Sieve analysis method.

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✲ Finness Modulus of Aggregate:-

→ It is the numberical value which gives the general idea about size of aggregates.

→ It is calculated by using following formula

$$\text{Fineness modulus} = \frac{\text{Commulative \% retained on sieve}}{100}$$

In above table,

$$FM = \frac{309.12}{100} = 3.09$$

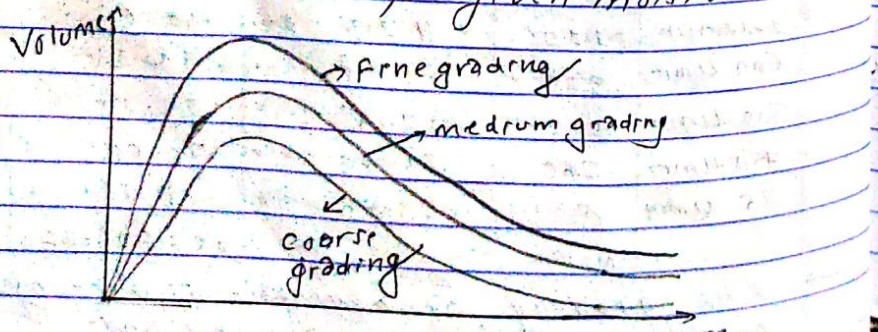
→ The value of fineness modulus is higher for coarser aggregate and less for finer aggregate.

✲ Bulking of Sand:-

→ The phenomenon of increasing the volume of sand due to the moisture present in the sand. The moisture present in sand tends to increase surface area due to surface tension. About 5-6% volume of sand is increased due to moisture content.

→ The bulking phenomenon is almost absent in coarse aggregate.

→ Fine the material, more will be the increase in volume for given moisture content.



- decrease strength of concrete
- prone to segregation.

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→ Bulking of sand play important role in manufacture of concrete. If the bulking is not considered, the concrete mix will be undersanded because the measured volume of bulk sand is greater than the actual volume of sand.

✲ Testing of sands:-

1) clay test:-

- The sand sample is taken in a glass jar & water is mixed, then stirred & allowed to settle. Any clay matter present in sand will form layer at the top of sand mass.

2) Test for Organic Impurities:-

The sand sample is taken in a testube and a solution of NaOH (caustic soda) is added. The mixture is throughly stirred. If organic matter is present in sand, the solution will take brown colour.

3) Test for salt:-

The presence of sulphates and other salts in sand will give bitter test, which can be easily detected.

✲ Testing of aggregate

1) water absorption:-

Some aggregate are taken & dust & cementing material are removed then dried. The dry wt is taken. Then immersed 24 hr in water then wt is taken. The change in wt to the original dry wt gives the water absorption of aggregate. Most of the concrete have 0.5-1% water absorption.

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2) Shape and size test:-
size ⇒ small ⇒ provide greater surface area for binding
shape ⇒ Angular with rough surface

3) Soundness test:-
→ Resistance of aggregate to change in volume with variation of environmental conditions. More the water absorption, more will be the change in volume.

4) Alkali Aggregate reaction:-
→ Actually, aggregate is not inert material. The aggregat reacts with alkalis present in sand so, durability of concrete reduces & crack appeared.

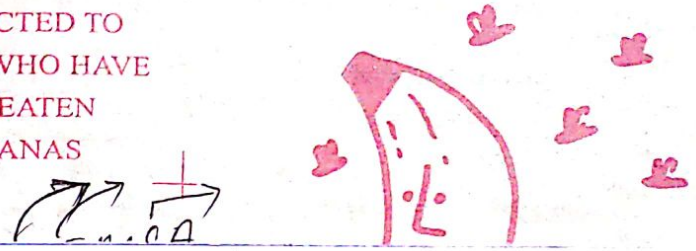
5) Abrasion test:- (16% AAV for good aggregate)
→ The resistance of aggregate to wear is known as abrasion test.
→ This test is performed by using Los-Angeles Abrasion test Machine.
→ The clear aggregate sample is taken & dried in oven. Then, it is placed in test machine with specified abrasive charge.
→ The abrasive charge is of cast iron sphere or steel sphere.
→ The aggregate with abrasive charge are rotated in the machine about 500-1000 revolution at the speed of 20-33 rev/min.
→ Then, the aggregate is taken out & washing & drying. Then, the final weight is noted.

Should be less than 20%

$$AAV = \frac{\text{orginal wt} - \text{Final wt}}{\text{Orginal wt}} \times 100$$

DO YOU KNOW...

QUITOS ARE
RACTED TO
E WHO HAVE
ST EATEN
ANANAS



→ (less than 30%)

6) Aggregate impact Value (Impact test).
→ Resistance of aggregate to sudden shock or impact is known as toughness of aggregate.
→ AIV is a measure of toughness of aggregate.

* The sample which passing through 12.5 mm IS sieve and retaining on 10 mm IS sieve is taken and dried in oven. Then it is filled with cylindrical container. let A be the weight of aggregate sample. This sample is placed in the impact load machine in which impact load is applied through 15 blows of standard hammers falling from a height of 380mm. The aggregate is taken out & sieved through 2.36 mm sieve. let 'B' be the weight of fraction passing through 2.36mm. Then, the AIV is,

$$AIV = \frac{B}{A} \times 100$$

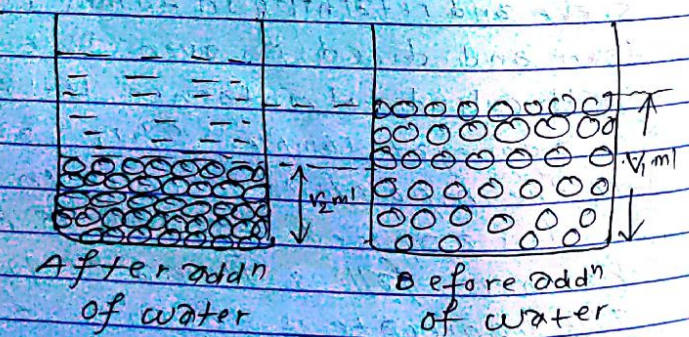
A = Weight of prepared aggregate sample.
B = Weight of aggregate passing through 2.36mm after applying load.

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2) Shape and size test:
size ⇒ small ⇒ provide greater surface
shape ⇒ Angular with rough surface

3) Soundness test:
Resistance of aggregate to
change in volume with varration

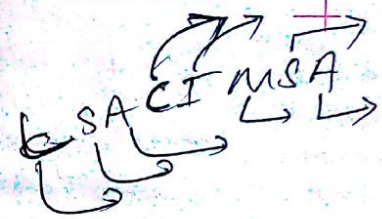
Bulking



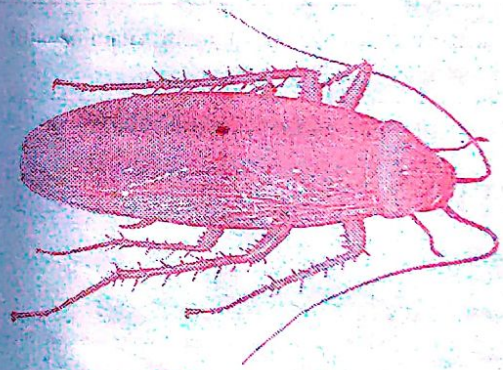
$$\% \text{ bulking} = \frac{V_1 - V_2}{V_2} \times 100\%$$

DID YOU KNOW...

MOSQUITOS ARE ATTRACTED TO PEOPLE WHO HAVE JUST EATEN BANANAS







A cockroach can live 9 days without it's head It only dies because it cannot eat.

Wearing Headphones For Just An Hour Will Increase The Bacteria In Your Ear By 700 Times.



DID YOU KNOW...

SPINACH SMART



- Spinach belongs to the goosefoot family along with beets and Swiss chard.
- Fresh spinach in available year-round.
- Spinach grows quickly. It can be harvested and eaten after only 37 to 45 days!
- California and Texas produce the most spinach in the United Sates. Spinach likes to grow best during the cool winter months.
- The whole spinach plant is packed during harvesting.
- Spinach is an excellent source fo many vitamins and minerals, especially folic acid.

Did you know... that leafy vegetables, such as spinach, contain more vitamins and minerals and lass calories than other vegetables.

YOUR BABY'S TEETH: MYTHS V/S FACTS

MYTHS	FACTS
1) cavities in baby teeth don't matter because they will just fall out any way....	1) Cildren don't lose their last baby tooth until they are close to 12 years old. Once started. Cavitles will grow bigger over time and eventually need to be filled.
2) cavities in baby teeth don't need fillings because they are just baby teeth....	2) cavities in baby teeth can can to pain and infectio. Cayries must be created by by the dentist and this can be very hard for young children
3) kids don't need to see the dentise until they are at least years old....	3) It is recommended that all kids see the dentise for the first time when their first tooth crapts orby age 1 year loses
4) I can twoice to start brushing my baby's teeth until he is older...	4) To privios cavities parents should being brushing their baby's teeth as soon as the first tooth comes in.
5) thooth pastel floride is dangraous for my baby....	5) Parent should use a small start of toothpaste with provide about the size of a grain of rice when brusing their baby's teeth. Tish small amount is not harmful small overd and will help prevent cavities.



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① Annealing:-
→ Heating and slow cooling of metal
→ increase ductility, easily workable
→ Modify electrical & Magnetic properties.

② Normalizing
→ Heating steel above critical range & cooling rapidly in air.
→ To refine grain structure

③ Quenching:-
→ Rapid Cooling of metal in oil or air or water
→ After quenching, the metal becomes hard.

④ Case hardening
→ If we required some part of metal hard & some part of metal is soft, tough & ductile, in this case, only certain part is cooled fastly after heating more than critical temp.

⑤ Tempering:-
→ The hardened steel obtained after Quenching is reheated below critical temperature & cooled slowly.
→ Tempering is done to achieve durability, strength, toughness, increase the hardness & wear resistance.

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TOR steel and TMT Bars.

TOR steel:-

- Twisted Ore reinforced steel
- deformed steel formed after twisting
- TOR steel have higher yield strength & higher bondage with concrete.
- Best grade of steel used in concrete reinforcement.
- More corrosion than TMT steel.
- TMT bar is good & have unique properties than TOR steel.

TMT bar:-

- Thermomechanically Treated bar
- produced by applying latest advanced technology
- change in properties like strength, durability, ductility, welding, bending property.
- ~~tempering~~ and Case hardening is done while preparing the TMT bar. (Outer surface is cooled quickly in water or oil & inner surface is cooled slowly in atmosphere) Due to which outer part of bar is hard and inner part is ductile.
- TMT steel bar are more corrosion resistant.
- Good bendability & weldability.
- Manufactured by advanced & Sophisticated heat treatment
- Higher value of yield strength compared to TOR.