LECTURE NOTE

ON

BMCT

FOR

DIPLOMA IN CIVIL ENGINEERING

(3RD SEMESTER STUDENTS)

AS PER SCTE&VT SYLLABUS

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CH-1: CEMENT

* INTRODUCTION :-

JOSHEP ASPDIN, Invent Portland cement in U.K. In 1824.

Used a mixture of Limestone, Clay & Water.

The mixure was heated at high temprature.

On 21st Oct, 1824 was granted a Patent.

Limestone + Clay + water $\xrightarrow{\text{high temp.}}$ Cement

* PORTLAND STONE :-

Properties of cement and portland stone are same.

Before Cement, Portland Stone used in Construction :-

Example → Pt. Pauls cathedral church

Cepotch in London Whole Hall.

* TYPE OF MATERIAL :-

CALCAREOUS (CaO)	ARGILLACESOUS Al_2O_3	SILICEOUS (SiO_2)
* Lime stone * Chalk * Marginal Shale * Cement Rock	* Shale * clay * Cement Rock * Blast furnace slag * chalk * Marl	* Sandstone * Silica.

* Basic Constituents of all the material on and inside of earth surface are :- Magnesia (MgO) SALIM

Lime (CaO), Silica (SiO_2), Alumina (Al_2O_3), Iron Oxide

Manufacturing Of Cement :-

Raw Material Excavation & Storage → Correction of Properties → Pulverization (Powdery form) In Ball → Calcination In Kiln [Heating] → formation of Clinker & Its Cooling → Pulverize Clinker & Add Gypsum → Storage & packaging

Note :-

Material heating in Higher temperature.

- Oxidation
- Reduction
- Compound are breaked into primary element
- Melting

→ **Calcination :-** Heating of substance high temperature but bellow Melting points.

→ It enable the substance to fuse [fusion].

→ In this process Gases (CO_2) is evolved.

→ Temperature is Kept around 1300 — 1400 °C in rotary Kiln.

MANUFACTURING OF CEMENT :—

1) DRY PROCESS 2) WET PRESSURE

FLOWCHART

DRY PROCESS

ARGILLACEOUS MATERIAL (Shale, Clay)

↓

CRUSHING (25mm) [JAW MILL]

↓

GRINDING [in Ball Mill) Tube mill]

↓

STORAGE

CALCAREOUS MATERIAL (Chalk, $CaCO_3$)

↓

CRUSHING (25 mm)

↓

GRINDING

↓

STORAGE

↓

MIXING (In correct proportion)

↓

PREHEATING (@ 800°C by exhausted gas)

↓

f_{eO} IN ROTARY KILN [Temp → 1400–1500°C] (@ 1–3 rpm)

Clinker size :- 3 mm – 25 mm

↓

COOLING [in DESICATOR]

↓ (Gypsum is Added by - 3-4 %)

GRINDING

↓

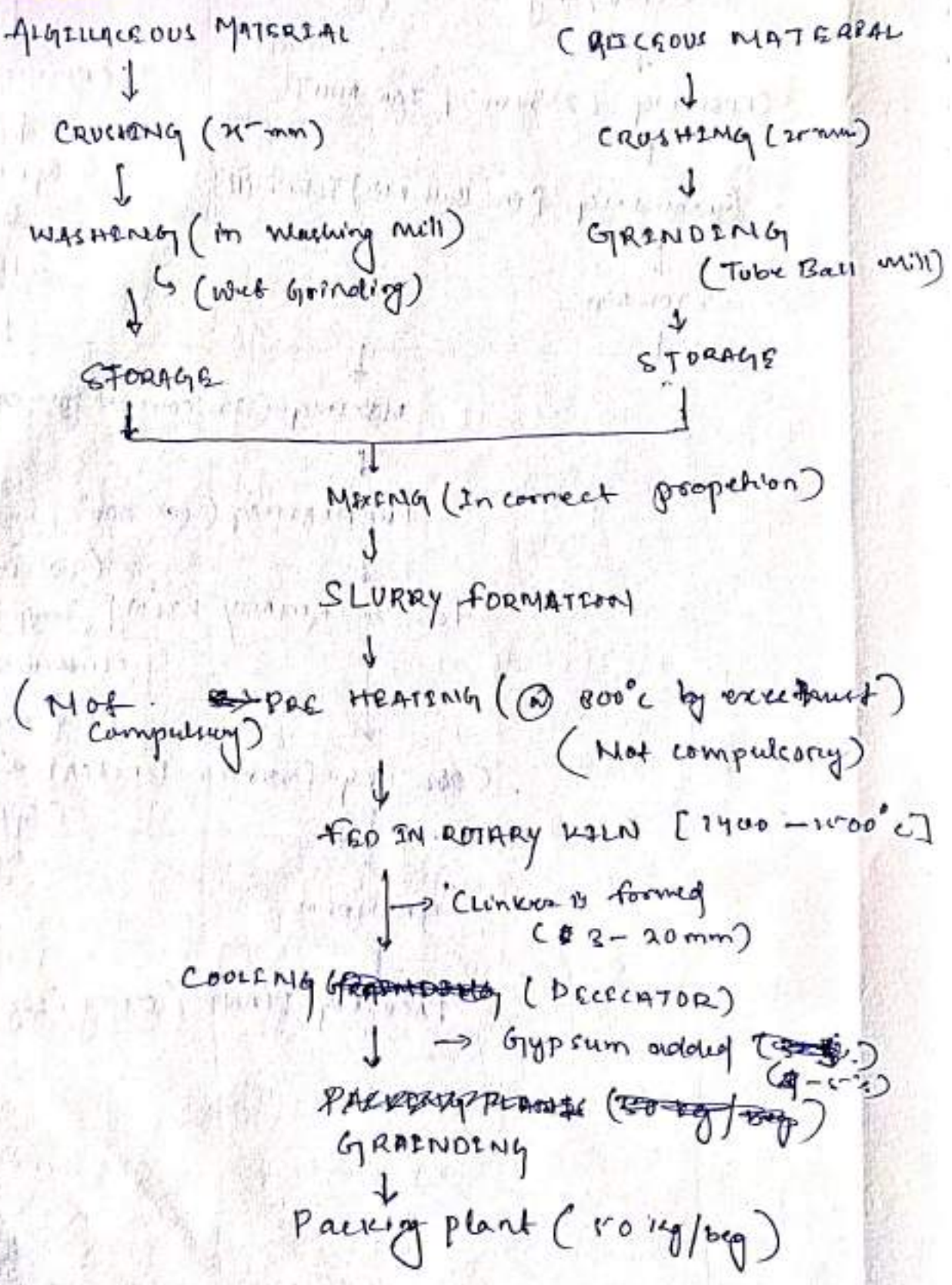
PACKING PLANT (50 kg/bag) / 35 Qt

Process Of manufacturing of Cement

Types

- Dry Process — temp (1300° — 1400°)
- Wet process. — temp (1400 - 1500°)

2. WET PROCESS



CONSTITUENTS OF CEMENT & THEIR ROLE :-

Constituents	functions	Average composition.
1. Lime (CaO)	Control Strength & Soundness. If lime decreases then strength and setting time decreases.	60–65 (63%)
2. Silica (SiO_2)	Give Strength, If increase if increases slow setting	17 – 25 (20%)
3. Alumina (Al_2O_3)	Responcable for quick setting, If it excess it lowers the strength.	3 – 8 (6%)
4. Iron Oxide (Fe_2O_3)	Gives Colour and helps in fusion of different ingredients.	0.5 – 6 (3%)
5. Magnesia (MgO)	Imparts hardness and Colour, If it excess of cause in mortar, concrete & leads to Soundness.	0.5 – 4 (2%)
6. Alkali (Soda + Potash) Na_2O & K_2O.	Residues, causes efflorescence and cracking.	0.5 – 1 (1%)
7. Sulphur Trioxide (SO_3)	Making Cement unsound	1–2 (1.5%)

Note: LSAIMAS → Main LSMM

Properties - effected by Consistituents

Strength → Silica, Lime.

Soundness → Resistance against volume changes

Cement Should Sound

↳ Lime, Magnatia, Sulphur trioxide,

Setting time → Lime, silica.

Silica: strength, Setting time ↑

* Lime ↑ → Setting time ↑ → Soundness ↑ → strength ↑

* FLY ASH (! %): - It also used as an admixture. these days to improve workability, But it Does not effect strength.

* GYPSUM (.2-3 %): - It is also added in order to increase setting time.

** CLINKER COMPOSITION: - **

When raw Material fuses in Kiln, the resultant compounds are produced is referred as Bouge Compound.

* no of Bouge Compound form → 4

for high strength development proper cooling:

1200°C → (15 min) → 600°C → (10 min) → Ambient temprature.

Principal mineral compound	Formula	Name	Symbol
1. Tricalcium silicate	$3CaO.SiO_2$ (1)	Alite	C_3S
2. Dicalcium ~~Aluminate~~ Silicate	$2CaO.SiO_2$ (3)	Belite	C_2S
3. Tricalcium Aluminate	$3CaO, Al_2O_3$ (4)	Celite	C_3A
4. Tetra Calcium Alumino ferrite	$4CaO Al_2O_3.Fe_2O_3$ (6)	Felite	C_4AF

C → CaO, S → SiO_2	A → Al_2O_3 F → Fe_2O_3	H → H_2O

La-3 :

~~Strength~~ ~~$C_3S > C_2S$~~

1) Tricalcium Silicate C_3S — (25 – 50) (average = 40)

* It provide best cementing properties and its formed when cement is well burnt.
* It provides early strength and responsible for 7 day strength.
* It enable clinker easy to grind & increase resistance to freezing and thawing.
* Generate high heat of hydration (H.O.H) and increase solubility of cement in water.
* H.Of. 500 J/gm

2. Dicalcium silicate, C_2S — 25-40% (average - 32%)

* It hydrates and hardens slowly and takes long time to add to strength that is later strength. (Ultimate strength)
* It enables clinker hard to grind & decrease resistance to freezing and thawing.
* Generate low heats of hydration and decrease solubility of cement in water.
* It imparts chemical resistance (Increase)
* H.O.H = 260 J/gm

Note:-
C_2S property are complimentry of C_3S.

3. Tricalciume Aluminate, C_3A - 5-11% (average- 10.5%)

* It react immediately with water and it is responsible for flash set. (Initial set)
* It is the first compound to react with water.
* It decrease the soffing time and, hance increase shrinkage & cracking.
* Its weakness resistance to sulphate attack.
* Volume change increase & decrease hance cracking (crowd mein)
* H.O.H increase & lower Ultimate strength
* H.O.H = 865 J/gm.

4. Tetracalcium Alumino ferrite, C_4AF — 8-14 % (average 9%)

* Responsible for flash set but generate less heat.
* Poored cementing properties.
* If increase, if decrease Strength.
* H.O.H = 420 J/gm

Note:-

* Heat of hydration :- When bouge Compound of cement react with the water with the addition of water to cement the process is refers as Hydration, At the time of Hydration the heat is generated so it called heat of hydration.
* Setting :- The process by which the cement get plastic nature to harden is referred as setting.
* Hardning :- Strength gain of cement after setting.

** HYDRATION OF CEMENT :-

* Chemical reaction of cement with water is known as hydration. which produce C-S-H gel. (Tobermorite gel)
* This reaction is high exothermic.
* Only C_3S and C_2S reacts with water to produce $C_3S_2H_3$ (Calcium Silicate hydrate) which is mainly responsible for Strength and densifie as cement set.

* Along with the CHS gel, $Ca(OH)_2$ is also formed as by product.

* $Ca(OH)_2$ is undesirable product because it causes sulphate attack.

* C_2S gives better cementing product then C_3S as it produces more gel & less $Ca(OH)_2$ in long term.

* Hydration of cement depend on!-

$C_3S \xrightarrow{H_2O} C_3H_2H_2\downarrow + Ca(OH)_2$

$C_2S \xrightarrow{H_2O} C_3H_2H_3\uparrow + Ca(OH)_2$

i) Ingredients

ii) fineness increase → Surface area increase → Rate of reaction increase

iii) Tamprature increase → Rate of reaction increase.

Note:-

* ORDER OF HEAT OF HYDRATION!- Amount of heat produced by 1 gm compound.

$C_3A > C_3S > C_4AF > C_2S$

862 502 420 260 J/gm.

* ORDER OF RATE OF HYDRATION! - Speed of reaction — Mass of compound reaction per second.

$C_4AF > C_3A > C_2S > C_2S$

* ORDER OF STRENGTH!-

$C_3S > C_2S \gg C_3A > C_4AF$

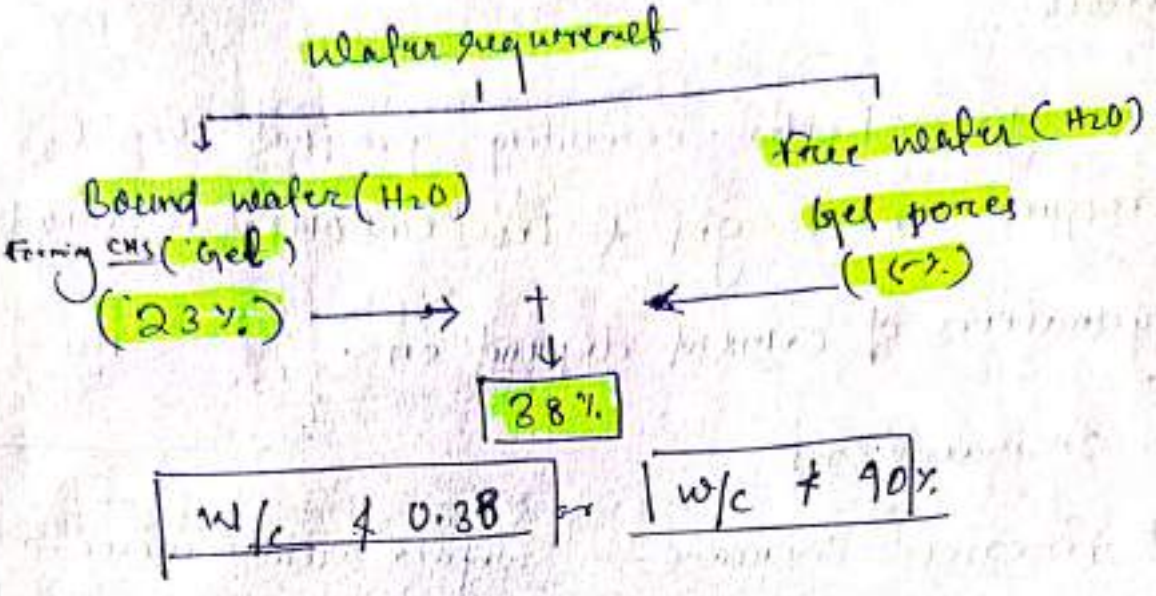
* ORDER OF SETTING TIME!-

~~$C_3A > C_4AF > C_3S > C_2S$~~ ✗

$C_3A < C_4AF < C_3S < C_2S$ ← assending order

Water requirement :-

$C_3S \rightarrow 24\%$ } average 28%
$C_2S \rightarrow 21\%$ }



Lec-9

Note :-

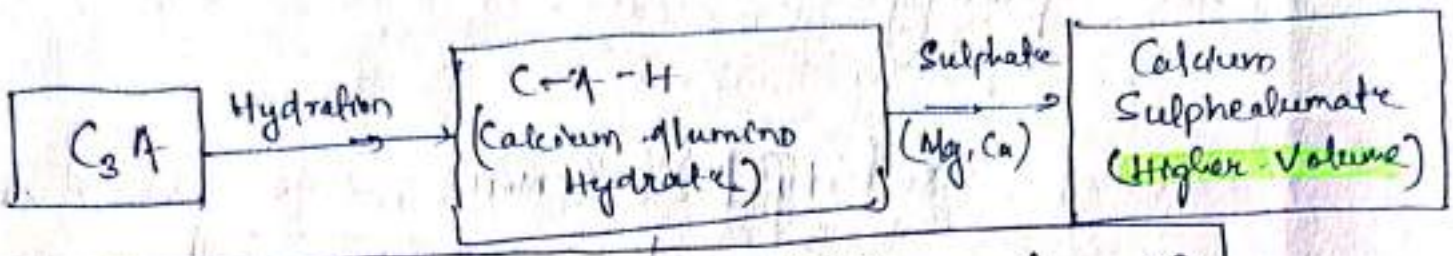
first compound to react with water - C_3A
Highest Heat of Hydration = C_3A
Rate of heat of hydration = C_4AF
Initial setting (flash setting) = C_3A
Sulphate Attack → C_3A

SULPHATE ATTACK :-

Source of Sulphate :-

- It occurs in Soil.
- Ground water
- & sea water
- PRESENT in brick.
- Bacterial Action in Sewers.

Soluble Sulphates doesn't effect severely Water Sulphates proves fatal as it react with gel & the volume of cement paste (gel) increase in concrete or mortar.



C_{3S} / $C_3\bar{S}$ + H → C-S-H (Tobemorite gel)

C_3A + H → C-A-H (Ettringite gel)

These end products causes increase in Volume 227% which causes the concrete to :—

1) Expansion
2) Extensive Cracking
3) Loss of bond between cement paste & aggrate.

* Gypsum (Calcium Sulphate) has to be controlled iipto 3%. (Because if it also leads to massive volume change.)

Gypsum ↑ → Setting time ↑ & Volume ↑ (Increase) → Develope Cracks.

TEST ON CEMENT

* Test are conducted to determine properties of cement & regular random stages in manufacturing for quality.

TEST ON CEMENT

- FIELD TEST
  1. Coulor
  2. Presence of lumps
  3. Strength
  4. Density
- LAB TASTING
  - IS 4031 — PHYSICAL TEST
    1. Fineness Test
    2. Consistency test
    3. Setting time test
    4. Strength
    5. Heat of Hydration
    6. Specific Gravity
  - IS 4032 — CHEMICAL TEST
    1. Loss in Ignition
    2. Chemical composition.

*) FIELD TESTING:-

* Cement Colour :) Greenish Gray
* If rubbed between fingures it should feel smooth not rough. [Rough → Sand mixed]
* If hand is inserted in bag on cement it should feel cool and not warm.

If thrown in a bucket of water it should sink and not to float on water.

A thin paste of cement should feel greasy between fingures.

It should be free from lumps (if present indicates absorption moisture from atmosphere), (More than 5% of lumps don't use that cement)

Briquettes (75 x 25 x 12 mm) made with 1:6 (cement:sand) proportion should not break easily kept under water for 3 days.

B) PHYSICAL TEST

I) FINENESS TEST :-

Fineness test (Indicates partical size of cement)

- Sieve test
  - 100 gm [Cement Sample]
  - sieve 90 μ (15 min)
  - Residue.

Cement	% Residue by weight
OPC	10
RHC	5

- Air Permeability Apparatus
  - Nurse & Blane's Apparatus.
  - Head Loss ∝ S.S.A = Surface Area / Mass / volume
  - (Specific surface Area.)
  - Head Loss { Cement 20cm sample.
  - Head Loss ∝ 1 / Size of particle of Cement

Cement	S.S.A (m²/kg)
OPC	225 (2250 cm²/kg)

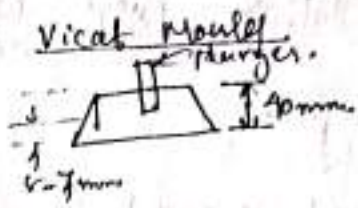
- Wagner Turbidmeter
  - ✗ Not Imp
  - Sedimentation Method

2. CONSISTENCY TEST (Vicat Apparatus)

(P)

* To determine Consistency of cement we use VICAT apparatus

* This test is use to determine the quantity of water mixing.



* Normal consistency (P) :- It is that percentage of water required, viscosity will be such that the Vicat plunger penetrates upto a point 5-7 mm, from the bottom of the mould.

* It is useful in performing other testing.

Range - P → 30%.

3. SETTING TIME TEST (VICAT apparatus) :-

Sample ↓
300gm + 0.85P

Setting time test

~~sample - 300gm + 0.6~~

- Initial setting Time
  - * Square Needle 1×1 mm is released and it penetrates only 5-7 mm from bottom of the mould.
  - * OPC not less then 30 min
  - * LHC = 1hr.
  - * Lime pozzolana Cement = 2hr.
- Final setting time
  - → The time at which middle make an impression but the annular collar fail to does is reffered as final setting time.
  - * F.S.T not less then 10hr

for OPC
I.S.T. → 30min
F.S.T. → 600 min (10 hr)

VICAT Attachment	Test
10 mm dia plunger	Consistency test
1 mm square needle	Initial setting test
5 mm dia annular collar	Final setting time

SOUNDNESS TEST :-

Soundness test → Change in volume of cement after setting

Sample → 100 gm cement + 0.78 P

Le-Chatelier's Apparatus

It measure unsoundness due to free lime only.

→ Unsoundness of cement should to 10 mm.

Procedure

24 hr (Normal water) take reading - x.

After that 3 hr in boiling water. take reading - y

$y - x \leq 10$ mm

Autoclave Test

→ Measure unsoundness due to both free lime & Magnesia only.

→ Expansion of cement should not be more than 0.8 %.

Specimen size - 25 × 25 × 282

Expansion ≯ 0.8%.

STRENGTH TEST :-

Strength test

Compressive Strength

Sample = Cement + Sand (1:3) + $\left(\frac{P}{4} + 3\right)$% water.

Tensile strength

→ Sample :- Cement + sand (1:3) + $(P/r + 2.5)$% water.

3 cube of size 70.6mm are prepared & gradually Compressive load applied.

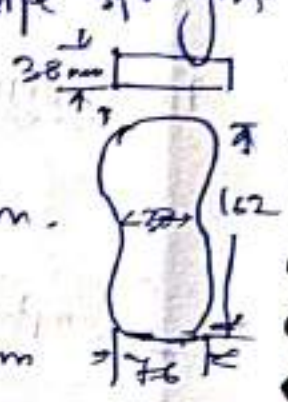
→ Average strength of 3 cubes is compressive strength.

Cube C/S Area = 5000 mm²
or 50 cm²

OPC → 33 N/mm²

→ 6 briquettes prepared & gradually aload as applied

→ Average of strength of 6 briquettes is tensile strength.



Neck → 38 mm.
Big width → 76 mm.
Low width. → 38
Length → 162 mm

6. HEAT OF HYDRATION :-

→ HoH is measured by Calorimeter.

7. SPECIFIC GRAVITY :-

Sp.g.r of Cement is measured by Le-Chatelier's flask. / Sl. fluid → Kerosene

OPC → Spgr - 2.15

Note

test	water
Initial setting time.	0.85 P
final setting time	0.85 P
Soundness test	0.78 P
Compressive strength.	$\left(\frac{P}{4} + 3\%\right)$
tensile strength test	$\left(\frac{P}{5} + 2.5\%\right)$

CHEMICAL TEST :-

1) LOSS ON IGNITION :-

→ 1 gm sample is heated in muffle furnance & loss in weight is observed. g which should not be more than 4% in general.

~~4%~~ for OPC ~~53~~
~~5~~ 5% for OPC 33/43

CHEMICAL COMPOSITION :-

→ Ratio of Al_2O_3 / iron Oxide should not be more than 66 %.

→ Weight of magnesia should not be more than 6%.

→ Lime Saturation factor should be between 0.66 – 1.02.

$$LSF = \frac{CaO}{2.8SiO_2 + 1.18Al_2O_3 + 0.65Fe_2O_3}$$

TYPE OF CEMENT

I. ORDINARY PORTLAND CEMENT :-

→ The common 3 grades are :- OPC 33, OPC 43, OPC 53.

→ 3 day strength = 50 % (1/2) of 28 days strength.

→ 7 day strength = 67 % (2/3) of 28 day strength

→ fineness = 2250 cm²/gm

→ I.S.T ≥ 30 min. & F.S.T. ≤ 10 hr (600 min)

Unit- strength- N/mm²

Grade	3 day	7 day	28 day
OPC 33	16	22	33
OPC 43	23	33	43
OPC 53	27	37	53

Category	Strength
(33) A	32.5 – 37.5
B	37.5 – 42.5
(42) C	42.5 – 47.5
D	47.5 – 52.5
(53) E	52.5 – 57.5
F	57.5 – 62.5

IS CODE – 10262

OPC 33 → IS 269
OPC 43 → IS 8112
OPC 53 → IS 669

IS 8041

CEMENT (REC) :-

→ C_3S is increased, C_2S is decreased + finer grinding.

→ Fineness → 3250 cm^2/gm [SA = Surface area / mass]

→ I.S.T = 30 min & F.S.T = 10Hr (600 min)

→ Uses – Road repair, in cold countries, for fast removal of cutter.

→ 1 day strength = 16 N/mm^2
3 day strength = 27.5 N/mm^2

Note:
It is not used for thin RCC members.

3. EXTRA RAPID HARDENING CEMENT (ERHC) :-

→ RHC + 2% $CaCl_2$ (Calcium Chloride)

→ Mixing + Transporting + Placing of concrete should be within 10 min

→ Accelerator = Calcium Chloride

Uses – Road repair, in cold countries, for first removal of cutter.

4. HIGH ALUMINA CEMENT :-

IS - 6452

Composition

Bauxite + limestone + iron oxide (increases fineness + high temprature)

Main compound of (HAC)

Oxide of Aluminium

→ It is similar to RHC but C3A is absent.

→ Use :- Road repair, in cold countries, for first removal of shutter, refractory cement (Heat resistance), High chemical resistance.

Viva → I.S.T = 3.5 hr, F.S.T = 0.5–6 hr

1day strength = 20 N/mm²

No sulphate attack due to C_3A is absent.

5. SULPHATE RESISTING CEMENT [SRPC] :-

IS – 12330

C_3A & C_4AF is (L) C_3S & C_2S (↑)

→ It is similar to OPC but C_3A is decreased + finer grinding. (Fineness ↑)

→ Used :- Lining of Sewers, canals, in costal areas, in water, Temprature is Less 40°C is used.

→ fineness = 4000 cm²/gm.

I.S.T = ≤ 30 min, F.S.T ≥ 600 min.

6. PORTLAND SLAG CEMENT :-

IS 455

→ Portland cement clinker + granulated blast furnace slag + Gypsum.

→ High chemical resistance (sulphate resistance), Low H.O.H.

→ Used :- Marine work, Notch & weir. (Low Rate of strength development)

Pig Iron —(Blast furnace)→ Blast furnace slag

CaO ↓, SiO_2 ↑
Al_2O_3 ↑, Low Fe_2O_3 ↓

7. LOW HEAT CEMENT (LHC) :-

IS : 12600

→ Low contents of C_3A & C_3S & more contents of C_2S.

→ I.S.T = 1 hr (60 min) & F.S.T = 10 hr (600 min)

→ Slow rate of hardening, slow strength development, prevent shrinkage & cracking decrease.

→ Uses :-
Mass Concreting work, high temperature place, (dam & Reservoire)

8. PORTLAND POZZOLANA CEMENT (P.P.C) :-

I :- 1489 - I

→ Portland cement + Pozzolanic material + (finer grinding)

→ fineness = 2000 cm^2/gm.

→ Pozzolanic Material :- fly Ash, Metakaolin, shale, (Siliceous Material) Silica fumes, Surkhi

→ Pozzolana (siliceous material) + $Ca(OH_2)$
= Pozzolana - Lime Compound (cementitious).

→ Low rate of strength development, decreasing in early strength, Low Heat of Hydration.

→ Cracking & Shrinkage (↓), Durability ↑, Permeability (↓) Segregation & Bleeding (↓).

Uses :-
Mass Concrete work, Marine work.

9. WATER REPELLANT CEMENT (HYDROPHOBIC CEMENT) :-

→ OPC Clinker + 0.1% oleic acid or, stearic acid

→ Use :- In basements, Water tight structure.
(Dams, spillways)

IS-8043:1991

10. WHITE & COLOURED CEMENT :-

→ from pure white ~~chalk~~ chalk + clay (free from iron oxide)
= white cement

→ Coloured cement = White Cement + 5-10% coloured pigment.

11: QUICK SETTING CEMENT :-

→ This cement is finer than OPC & Gypsum is not used.

→ I.S.T. = 5 min & F.S.T. = 30 min

→ Use :- In running water or under water structure/
structure

12: SUPER SULPHETED PORTLAND CEMENT :- [IS 690]

Composition
→ 80-85% granulated slag + 10-15% ($CaSO_4$) + 5% clinker.

→ Used bellow 40°C

→ fineness = 4000 cm^2/gm.

→ Soundness < 5mm.

Use :- High chimical resistances, Sulphate resisting.

13. AIR ENTRAINING CEMENT :—

→ OPC + Vinsol resin / Air entraining agent.

→ freezing / thawing resistance (↑) / Resisting frost action.

Uses

Pavement & Road, Bridge and overpass.

Airport runway, Dam & hydraulic Structure on cold area.

C-H-2 # CONCRETE

IS CODE - 1S456:2000 ← Redy Mix.

IS 10262 → Mix design (2009)

** (cement + fine Aggregate (sand) + Course Aggregate (Gravel) + water. + Supplymentary of cementing material → Concrete.

* Classification of Concrete based on properties *

1) Basis of Strength

- Low strength → ($< 20\ N/mm^2$)
- Medium strength → ($20 - 40\ N/mm^2$)
- High Strength → ($> 40\ N/mm^2$)

Concrete. Nominal Mix

2 Basis of Bulk density

Concrete	Bulk density
Extra light weight	$< 500\ kg/m^3$
Light weight	$500 - 1800\ kg/m^3$
Dense weight	$1800 - 2500\ kg/m^3$
Superheavy weight	$> 2500\ kg/m^3$

* MANUFACTURING Of CONCRETE :-

I. BATCHING :-

→ Aggregate, cement & water measured

→ There are two method of batching :

a) Weight Batching (Important project)

b) Volume batching (Small project)

Standard gauge box - 35 lit.

To a homogenous & uniform mixture, we mix Con

2 ways:-

a) hand mixing → 10% cementious material (by)

b) Machine Mixing

- IS 456 suggests approximately mixing time of at least 2 mi

- In gen generally, 20 revolution of concrete is m provided sufficient mixing.

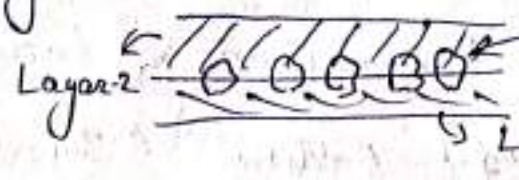
TRANSPORTING:-

- Pans → Transit mixer → V = 4
- Wheel barrows → Belt Conveyors
- Tower bucket
- Dump truck
- Concrete Pump — [Vertical dist → 80 m. / Horizontal dist → 400 m.

PLACING:-

Beam, Column, Slabs, Highways, Runways.

Mass concreting → Dams, Bridges .etc.



Underwater Concreting :- Tremie pipe (very lit

Slump Value taken around 150 — 200 mm).

5. COMPACTION :-

→ The process of removal of air voids & to make of dense.

→ It done in following ways :-

a) Hand ramming

b) by Giving shocks and Pressures

c) Mechanical Vibration :-

1) Needle vibrator
2) Shutter vibrater
3) surface vibrator
4) Vibrating table.

6. FINISHING :-

→ The process of leveling & smoothing the top surface of freshly placed concrete.

→ Screeding, floating & trowelling is done.

7. CURING :-

→ Cement gain strength & hardness because of water hence the pores should remain saturated.

→ To compensate loss of water & reduce shrinkage, cracking

→ As per IS 456 minimum curing period in 7 days at 90% humidity. (27°C)

→ Methods :-

1. Spraying water
2. Gunny bags
3. Ponding
4. Steam curing

Method Of Curing :-

1. Sprinkling Water (vertical member.)
2. Gunny bag → The best curing way for a vertical member of a structure is covering with wet gunny bags are covered and frequently sprayed water.
3. Ponding → Costly
4. Steam Curing → rapaid developement of strength
   → Used for precast Member / Structure.

WATER CEMENT RATIO :-

[It is the ratio of the mass of water to the mass of cement added to concrete]

According to Abharm's Law :-

Strength of fully compacted concrete is inversely proportional to w/c ratio.

$$\text{Strength} \propto \frac{1}{w/c \text{ ratio}}$$

Note :-

$0.4 < \frac{w}{c} < 0.6$

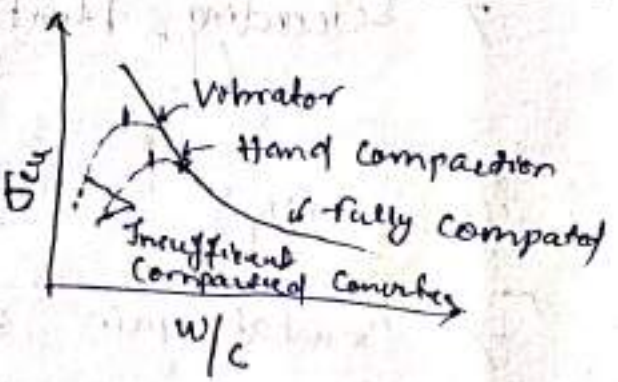
If $\frac{w}{c} < 0.4$ → honicombing

If $\frac{w}{c} > 0.6$ → least strength.

fully compacted concrete →

$$\text{strength} \propto \frac{1}{w/c}$$

Insufficiently Compacted concrete.



$$\text{Strength} \propto \frac{1}{w/c}$$

→ after point of maximum compressive strength

STRENGTH OF CONCRETE :-

I. COMPRESSIVE STRENGTH :-

Procedure :- IS-516

→ Test specimens 150 × 150 × 150 mm is recommended as per IS code.

→ Mixed concrete is filled in mould in 3 layer 50 mm, each layer tamped 35 times (for 15 cm cube) with bar of 16 mm & 600 mm long.

→ Test specimens are stored at a temp. of 27 +/- 3°C. 90% humidity for 24 hour form time of addition.

→ After these remove from mould & place in water for 28 days & before testing

→ Compression testing machine should be apply gradual load of 14 N/mm² per minut. until specimen is crushed.

Uniaxial comp. Load → [□] → Strength of each Cube rounded off to nearest 0.5 N/mm²

→ Compressive strength of sample → 3 specimen (Average)

→ The average of 3 values is taken as Compressive strength.

→ Addition Sample (After 7 days) → Expected strength after 7 day = 67 % of fck

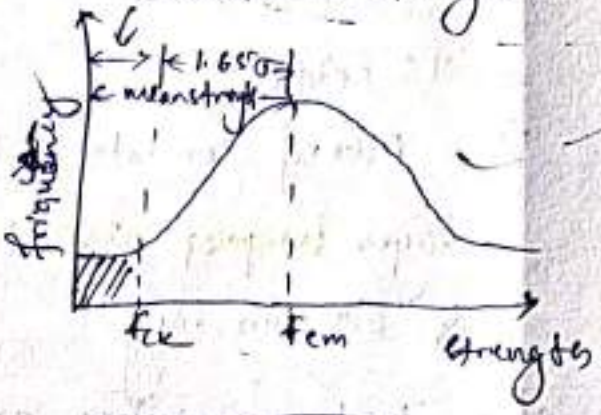
Expected strength of → 99% of fck

Characteristic Compressive Strength :-

Characteristic Compressive Strength is that strength below which not more than 5% of test results are expected to fall.

Mean strength $f_m = \frac{\Sigma f_i}{n}$

Standard deviation $\sigma = \sqrt{\frac{\Sigma (f_i - f_m)^2}{n-1}}$



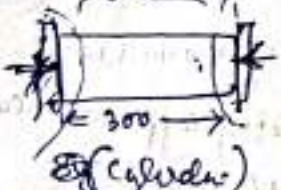
$$f_{ck} = f_m - 1.65\sigma$$

Gaussian Normal distributive Curve

$f_i < f_{ck}$ ⇐ 5%

$f_i > f_{ck}$ ⇒ 95%

Note :- No effect of restraining effect.



Restraining effect by steel in concrete.

Cube Strength = 1.25 × Cylinder Strength

Cylinder strength = 0.8 × Cube strength

L/B Ratio	1	0.3	2
Relative strength 150 mm	1	1.5	0.8

2. FLEXURAL TENSILE STRENGTH

↳ Bending stress

* It indicates modulus of rupture or tensile strength of Concrete in bending.

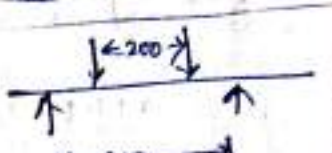
$$f_{cr} = 0.7\sqrt{f_{ck}}$$

From IS Code

Specimen
↳ Size → 150 × 150 × 700

$$f_{cr} = \frac{PL}{bd^2} \quad (a > 200\ mm)$$

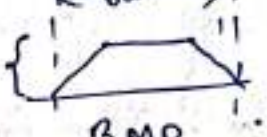
four point Loading

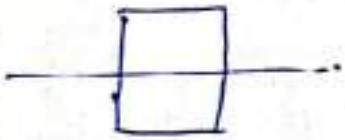


or

$$f_{cr} = \frac{3Pa}{bd^2} \quad (200 > a > 170)\ mm.$$

3rd point Loading





$$\frac{M}{I} = \frac{f_{cr}}{y}$$

$$\frac{\frac{Pl}{8}}{\frac{bd^3}{12}} \times \frac{d}{2} = \frac{f_{cr}}{1} \Rightarrow \boxed{f_{cr} = \frac{3PL}{bd^2}}$$

$f > f_{cr} \Rightarrow$ Cracking
$f < f_{cr} \Rightarrow$ Non-Cracking

3. SPLIT TENSILE STRENGTH :-

→ There is a standard test to measure tensile strength in indirect way.

Note :- Concrete is not tested in direct tensile (Recomandation)

Compression direct applyed due to compression the other deviction tensile indirect tension will be Generated.

$$f_t = \frac{2P}{\pi DL}$$

P → Compressive load (Ultimate)

D → Diameter of cylinder ($\frac{150}{mm}$)

L → Length of the cylinder (300 mm)

* Order of strength :—

Direct tensile < Split tensile (f_{ct}) < flexural tensile (f_{cr}) < Compressive strength (f_{ck}).

$$f_t < f_{ct} < f_{cr} < f_{ck}$$

$$f_t = 0.1 f_{ck} \text{ to } 0.2 f_{cr}$$

$$f_{ct} = 0.66 f_{cr}$$

* FACTOR AFFECTING STRENGTH OF CONCRETE :-

1) Size of specimen (↑) → strength ↓

2) Moisture Content → Partially saturated concrete has highest strength.

3) Air void (↑) → Strength (↓)

4) Rate of Loading (↑) → Strength (↑)

5) Age of cement (↑) → Strength (↓)

6) Degree of Compaction (↑) → Air void ↓ → Density ↑ → strength (↑)

7) Type of Aggregate [Well graded (Greater void)

WORKABILITY :- [Study]

→ It is defined as amount of useful internal energy required to produce full compaction.

→ Ease during mixing, placing, transporting, compacting, etc.

$$\text{Workability} \propto \frac{1}{\text{Compaction energy}} \propto \frac{1}{\text{Air void}}$$

Void ↓	SF ↓	Gel requirement Less	More workable
Void ↑	SF ↑	Gel requirement more	Less workable

* Factor affecting Workability of concrete :-

1) ~~More~~ water cement ↑ → Workability ↑

2) Texture of aggregate ↑ → Workability more (for Smooth)
Workability Less (for Rough)

3) Size of aggregate → a) ~~Smooth~~ Coarse → SF ↓ → void ↓ → Gel req Less
Less Workability b) fine → SF ↑ → void ↑ →

* More lubrication for coarse aggregate for workability more.

4) Shape of aggregate →

Angular	Round
Less void	More void
More Less workability	More workability

5) Grading of aggregate →

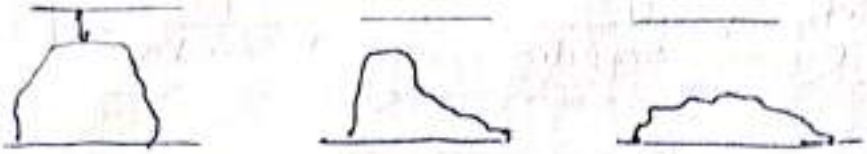
well graded	Poor Graded
Less void	More void
More Less workability	More workability.

MEASUREMENT OF WORKABILITY

1. SLUMP TEST :-

This is the most commonly used for measurement medium to high workability.

Slump Value & Workability



True slump — Shear slump — Collaps slumps

Use	Slump Value (mm)	
for road construction	20–40	Low
Mass Concreting	25–50	
Beam & Slab	80–100	medium.
Normal Rc work	80–150	Huge > 150
Concrete to be vibrated	10–25	Low

Slump (max)	Workability.	
0–25	very Low	x
25–50	Low	
50–100	Medium	
100–150	High.	
> 150	V. High.	x

2. COMPACTING FACTOR TEST :-

It is lab test & used to measured workability having Low to medium slumps.

**

Compacting factor (C.F) :- $\frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete.}}$

Workability $\propto$ C.F

***

Workability	C.F.	Slump value (mm)	Remark
Very Low	0.78	0 – 25	Road - Pavement
Low	0.85	25 – 50	foundation work
Medium	0.92	50 – 100	RCC
High	0.95	100 – 175	R.C.C (High Reinforcement)

3. VEE-BEE CONSISTOMETER TEST :-

→ It is used to measure workability of very low to low.

→ The time required for the shape of concrete to change from slump shape to cylindrical shape is known as Vee-Bee-degree.

***

Vee-bee degree $\propto \frac{1}{\text{workability}}$

****

Workability	Vee-bee degree (Bee)
Extreamly dry	32 – 18
Very stiff	18 – 10
Stiff	10 – 5
Stiff plastic	5 – 3
plastic	3 – 0
Flowing	–

4. FLOW TEST

→ It is test is used to measured workability having high to very high slump.

$$\text{flow } Q(\%) = \frac{\text{Spread diameter (cm)} - 25}{25} \times 100$$

flow (%) ∝ workability

Note-table.

Workability	Test to preferd
Very Low - Low	Vee-bee Consistometer Test
Low - Medium	Compacting factor Test
Medium - High	Slump test
High - Very High	flow test

✱ ADMIXTURES :-

- Admixture
  - Chemical Admixture (added in Concrete)
    1) Plasticizer / Superplasticizers
    2) Accelerators
    3) Retraders
    4) Air Extraener
  - Mineral admixture (Added during manufacturing of cement)
    - Pozzalana
    - Surkhi
    - Blast furnace slag

1) a) PLASTICIZERS :-

→ It Improve plasticity of fresh concrete.

→ It improve workability for a given w/c ratio.

→ To achive higher strength for given w/c ratio.

→ It reduce water requirement by 10%.

Example :- Lignosulphonic Acid, hydroxylated carboxylic Acid.

Process

→ It has slower setting effect.

Dose :- 200 to 400ml per 100 kg of cement

2. ~~Super~~

II(2). SUPER PLASTICIZER!-

→ They produce flowing Concrete.

→ Similar in action to plasticizer.

→ It reduces the water requirement by 20-40%.

Example!- Sulphonated melamine formaldehyde Condensates, Modified lignosulphates etc.

2. RETARDERS!-

→ These slow down the chemical reaction of cement & water.

→ It increases setting time & slow down initial strength gain.

Example!- Sugar, lignin, phosphates, tartaric acid etc.

Use→ Whether concrete should be transported for long time.

3. ACCELERATORS!-

→ These speed up the chemical reaction of cement & water.

Example Calcium Chloride ($CaCl_2$), NaCl, NO_2SO_4, NaOH etc.

Use!- Higher early strength, Rapid removal of formwork, Cold countries.

4. AIR ENTRAINERS:-

→ It introduces air in form of tiny Ø bubbles distributing uniformly.

Example:- Neutralised virsol resin, wood resins, animal/veg. fats, Aluminium power, etc.

Imp → Air entrainer (↑) ∝ 1/strength ↓ ⇒ lubrication ↑ ⇒ Workability ↑

→ Forming/thawing Resistance ↑ ⇒ Shrinkage ↓, Bleeding ↓ Segregation ↓

⇒ Weight ↓

USES:- Improve workability, reduce bleeding & segregation.

5. Bleeding Agents.

6. Water proofers

8. Pozzolana.

✱ DURABILITY OF CONCRETE:-

→ If concrete serves it purpose for entire design life in any external exposure condition, it is said to be durable.

Factor affecting Durability:-

→ Permeability

→ freezing & thawing

→ Sulphate Attack

→ Acid and oils

→ Sewage (H_2S) → SO_4^{2-}

→ Frost action

To improve durability

Cement content ↑

↓

W/c Ratio ↓

↓

Grade ↑

ADMIXTURES

6. Bleeding Agents → Aluminium sulphate, paraffin wax.

7. Water proofers → wax, Coal tar, Calcium stearate.

8. Pozzolana :- to reduce water content by 3-5% ; ex- fly ash.

9. Expansion producing admixture :- to counteract drying shrinkage, Eg- Granulated Iron.

✱ DEFECTS IN CONCRETE

1. CRACKS :-

→ It occurs due to unsound material, freezing and thermal effect, High w/c ratio.

→ It reduce durability

→ Acceptable limit of cracks width is 0.1 - 0.2mm.

× Classification of Exposure Condition :-

Environment Condition	Permissible (Clear) Cracks
Mild →	0.3 mm
Moderate →	0.2mm.
Severe →	0.1 mm
Very severe →	
Extreme →	

Mild
Moderate
Very severe
Extreme

→ Appearance of white fluffy patches on concrete surface because salts leaches out & deposite on surface.

H_2O Sulfate	NO_2O
	K_2O

3. SEGREGATION :-

→ When coarse aggregate, fine aggregate & paste seperate from ~~each~~ each other.

* Causes :- Dropping from height, excessive vibration, Bad mixing design.

Maximum dropping height → 1.5 m

* ~~for~~ safe :- → Reduce size of coarse aggregate.
→ ~~Use~~ Add air entraining admixture.
→ Pozzalana.
→ Proper ~~design~~ mix. design
→ Optimum Compaction.

4. BLEEDING (LETANCE) :-

→ When mixing water flows out from the surface.
~~for~~ from freshly placed concrete is usually due to.
excessive ~~vibra~~ ~~Compaction~~ vibration to achive full ~~strength~~ compaction.

→ It leads to formation of pores inside which.
Causes Less Strength.

* (for prevent ~~bleed~~ bleeding same as segregation)

2. Aerated Concrete :-

* It is manufactured for calcareous and siliceous materials like cement, lime, pulverized sand, fly ash etc. by entrapping air cells.
* These entrapped air cells make the material light, impervious and a good insulator of heat.

3. Heavy Weight Concrete :-

* It can be produced by using specially heavy weight aggregates and by compacting well.
* These concrete can be suitably used for gravity dams, retaining wall construction, atmospheric atomic power plant vessels etc.

4. Pre-Packed Concrete (PAC)

* It is obtained by injecting cement-sand mortar under pressure to fill void voids of already packed and fully compacted coarse aggregate.
* The concrete is quite dense and has very small shrinkage

5. Fiber Reinforced Concrete :-

* Along with main ingredient, discrete fibres are also added.
* FRC is tougher and more resistance to impact.

6. SELF. COMPACTING CONCRETE :-

7. FERRO- CEMENT :-

→ Cement concrete + wire mesh (0.1 - 1mm dia)

→ It enhances ductility of concrete.

8. IRS - T40 Cement

8. VECUUM CONCRETE :-

→ In this type of concrete extra water is removed by vacuum pressure.

9. Shotcrete / Gunite :-

Concrete applied under pressure through gun or hose.

10. Cyclopean Concrete :-

Concrete + (~~large~~ large stone embeded in it)
by size ≥ 15 mm

11. Ready mix Concrete :-

→ It is manufactured in building plant and transported to site through transit mixture.

12. Green Concrete :-

Manufacturing by using waste industrial waste, material.

like → fly Ash., Blast furnace slag. etc.

MIX DESIGN (Imp)

* We have to find quantity of ingredients such as cement, fine aggregates, coarse aggregate, w/c ratio in order to produce 1 m^3 concrete of desire strength and durability.

Design Mix	Nominal Mix ($\leq M_{20}$)
Code - IS 10262	Code - IS 456
* Economical	* Uneconomical
* It is more close to field	* It is not real situation
* Quality of ingredient is considered.	* Quality of ingredient is not considered.
Mix proportion	Mix proportion

* Note:-

* Imp:- Table no-5 (IS 456:2000)
Minimum (Cement content, w/c ratio, Grade of concrete) for different exposer cond. environment condition.

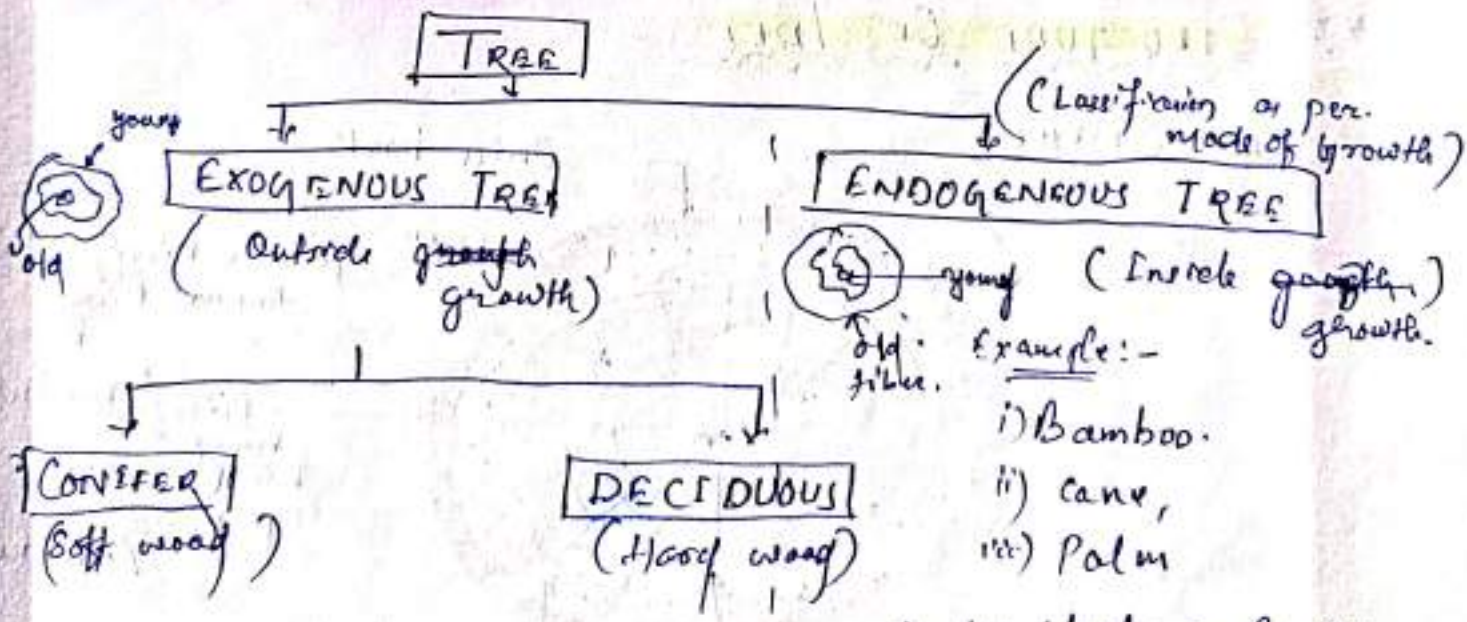
* Table-no-3 (IS 456:2000)
(Exposer conditions) for

Nominal Mix	Proportions
M_{5}	1:5:10
~~M_{10}~~ $M_{7.5}$	~~1:4:8~~ 1:4:8
M_{10}	1:3:6
M_{15}	1:2:4
M_{20}	1:1.5:3
M_{25}	1:1:2

CH-3: TIMBER

* INTRODUCTION [wood prepared for use in building and carpentry]
* Benifit of timber :-
  - → Efficient & first installation.
  - → Environment friendly.
  - → Easy to craft with hand.
  - → High strength/weight ratio.
* Disadvantages :-
  - → Decay (Timber decay is caused by a biological attack within the wood by certain species & fungi)
  - → Variation in strength
  - → Moisture changes can effect the timber.
  - → Not a isotropic material.

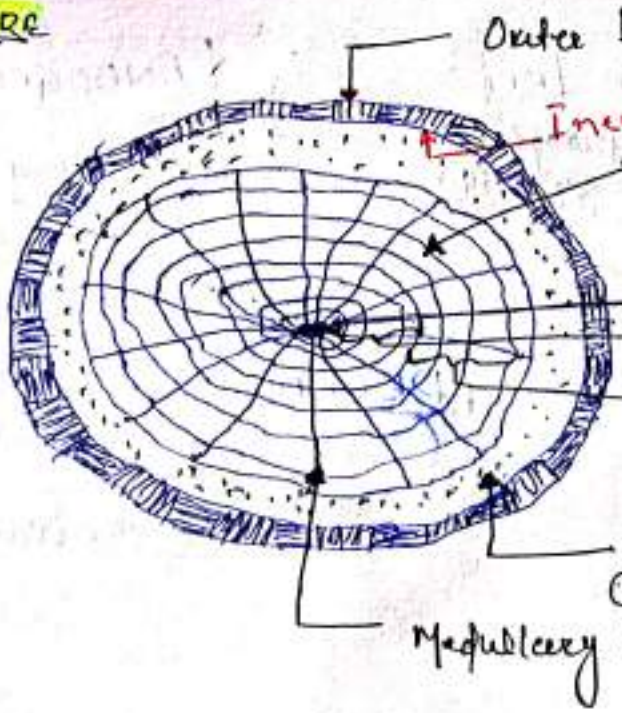
CLASSIFICATION OF TREE



Property	(Conifer) Soft Wood	(Deciduous) Hard Wood
Colour	Lighter	Darker
Growth	Faster	Slower
Weight	Lighter	Heavier
Density	Low	High
Conversion	Easy	Difficult
Resinous Material	Exist	Do not Exist
Annual Ring	Distinct	Indistinct
Example :—	Chir, fir, deodar etc.	Teak, sal, Shisham etc.
	Kel, pine, Larch	Oak, poplar, maple. Mogony.
	* Needle shape Leaves (Evergreen)	* Broad shap leaves (Seasonal)
Medullary Ray	Distinct	Distinct.

STRUCTURE OF TREE

MACROSTRUCTURE



> MICROSTRUCTURE!-

2) Conductive Cells → It conduct food and water (liquid) vertically

3) ~~Support~~ Mechanical Cells!- It provides mechanical strength and rigidity to trees.

3.) Storage Cells!- It stores food and nutrients and transmits in horizontal direction.

PROPERTIES OF TIMBER!- (Characteristics of Good timber)

1. DENSITY & SPECIFIC GRAVITY!-

→ The average density (apparent specific Gravity) range from 450 – 950 kg/m³. (< 1000 kg/m³)

→ The true specific gravity of wood = 1.54.

2. MOISTURE CONTENT!-

→ It is hydroscopic in nature.

→ Recommended moisture content for structural element is 10-20%.

→ Drying below fibre saturation point causes shrinkage.

drying → Cell cavities (50%) → No volume changes
↓ (FSP)
fiber → Volume changes occurs

Cell → free water (cavity water (not causes volume changes))
Bound water (causes Volume changes)

→ Timber has high sound conductivity
→ Speed of sound ranges 3000 - 5000 m/s.

4. HEAT CONDUCTIVITY :-
→ It is low
→ More along fibers than across fiber.

5. ELASTIC MODULUS :-
→ It ranges between 5000 - 11500 KN/m³.
→ Longitudinal direction > transverse direction.

Note :- 1
On the basis of Modulus of elasticity timber can be classified into 2 types.
that are Class-A [E > 12.1 KN/m²]
Class-B [E → 9.8 to 12.1 KN/m²]
Class-C [E → 5.6 to 9.8 KN/m²]

Note- 2
Wood is anisotropic or Orthotropic.

6. STRENGTH OF TIMBER :-

A: TENSILE STRENGTH
(11) Along the fibers > Across the fibers ($\perp^r$)

B: COMPRESSIVE STRENGTH :
(11) Along the fibers < Across the fiber ($\perp^r$)

C: SHEAR STRENGTH :-
(11) Along the fibers < Across the fibers ($\perp^r$)

Note - 1

Order of Strength

Tensile strength > Bending strength > Compressive strength

→ Tensile strength 2 to 4 times of compressive strength

Note - 2 (Shrinkage)

Circumferential shrinkage. > Radial shrinkage
> Longitudinal shrinkage.

** * CHERESTERETICS OF GOOD TIMBER:

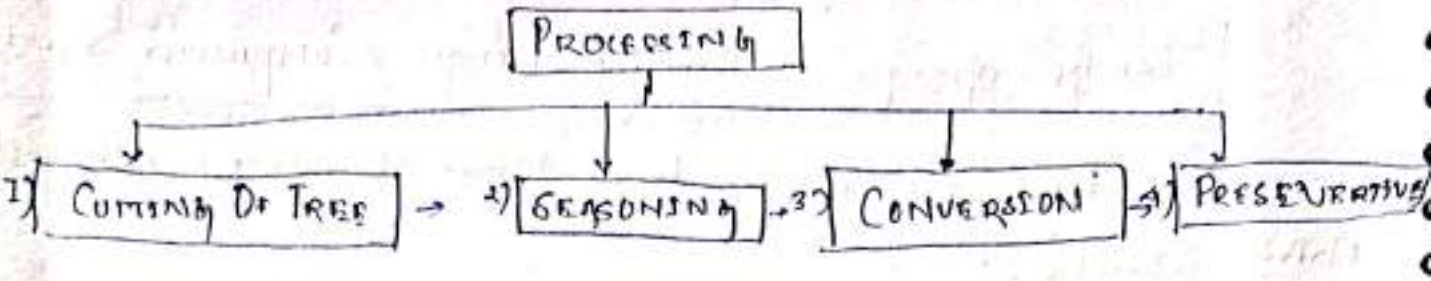
→ High strength.
→ Durable
→ High fire resistance
→ Sweet smell
→ Clear ringing sound. (not dull sound)
→ Straight fiber.
→ Tough (High impact resistance)
→ Hard Medullary Rays (should be able to hold annual ring properly)
→ Regular annular rings & dense.
→ Low water permeability.

Note - 3

Classification of timber: (On the basis of Durability)

durable	Avg. life span
1) Low	< 60 Month.
2) Medium	60 – 120 Month
3) High	> 120 Month.

PROCESSING OF TREE TO TIMBER



Note: On the basis of position, timber Classification.

1) ~~Standard~~ Standing timber → Standing tree
2) Rough timber → Part of fallen tree
3) Converted timber → Converted into rigid log of wood by lumberjack.
   (log of wood = Lumber)

DEFECTS IN TIMBER:-

A → Defect due to Conversion
B → Defect due to fungi
C → Defect due to insects.
D → Defect due to natural force.
E → Defect due to seasoning.

A: DEFECT DUE TO CONVERSION:-

1) Chip Marks:- Indicate by marks or signs placed by chips on the finished surface of timber.
2) Diagonal grain:- Form due to the improper Sawing of timber

formed on the finished surface of timber by falling of a leaf or so.

* Wane :- Denoted by presence of original rounded surface on the manufactured piece of timber.

B: DEFECTS DUE TO FUNGAI :-

* Blue Stain :- Sap of wood is stain to blue colour by the by action of certain type of fungi.

* Brown rot :- fungi of certain type remove cellulose compound from wood and hence the wood assumes the brown colour.

* Dry rot :- fungi of certain type feed on wood and drying feeding, then attack on wood and convert in to dry powder form.

- It happens due to unfavourable wetting and drying condition when are in no free circulation of air.

* Heart rot :- heart wood is exposed to the attack of atmospheric agents : free becomes weak and it gives outer hollow sound where when it struck with a hammer.

* Sap stain :- Certain type of fungi feed on cell contents of Sap wood : sap wood loses its colour.

* Wet rot :- Some fungi cause chemical decomposition of wood ; convert to greyish brown powder.

* White rot :- Certain type of fungi attack lignin of wood ; wood assumes appearance of white mass containing of cellulose compound. It is opposite of brown rot.

C. DEFECTS DUE TO INSECTS :-

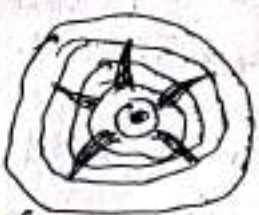
* Beetles :- Form pin hole of about 2mm dia
* Marine borers :- diameter of the hole made by them is about 2 mm.
* Termites / white ants :- eat away wood from core of the cross-section.

D. DEFECTS DUE TO NATURAL FORCES :-

* Chemical Stain :- Wood gets discolored by chemical action caused with it by some external agency.
* Knots :- There are base of branches or limbs which are broken or cut from tree. The portion from which branch is removed receives nourishment from them and it ultimately result in the formation of dark hard rings which are known as ~~Knots~~ Knots.
* Shakes :- Cracks which partly or completely separate the fiber of wood.

Type of shakes :-

(Cupshakes)



(Heart shakes)

(Ring shakes)

(Star shakes)

* Callus :- Indicate soft tissue around wound.
* Rind galls :- Indicate abnormal growth, peculiar curve swellings. It develops when branches are improperly cut off.
* Twisted fibers :- Comes by twisting of young trees by fast blowing wind.
* Upset :- Ruptures occur when fiber are injured by crushing or compression.
* Burls (excrescency) :- Formed when a tree receive shock in it young age, irregular projection apear on body
* Wind cracks :- Shrinkage of external surface lead to cracks.
* Foxiness :- Red or yellow tinge formin the surface of timber nearest to pith.
* Druxiness :- White decayed spots are formed in surface of timber.

6. DEFECTS DUE TO SEASONING :-

* Bow :- Indicated by curvature formed in direction of length of timber.

* Cup :- Indicated by curvature formed in transverse direction of timber.

* Case-hardening :- Exposed surface of timber dries rapidly, therefore shrinks and in under compression, interior surface in under tension.

* Check :- Check crack which seperates fibers of wood; does not extend from one end to other.

* Split :- When a check extends from one end to other.

* Twist :- When a piece of timber has to spirally distorted along its length.

* Warp :- When a piece of timber twisted out of shape

SEASONING OF TIMBER :-

Process of reducing the moisture content of freshly cut trees (Moisture 50-60%) to make it suitable for use. (10-12% moisture) ~~content~~.

* Objectives of Seasoning :-

→ Reduce shrinkage & warping.

→ To increase strength, durability, workability of dimensional stability.

→ Makes it suitable for painting.

→ Protection agent fungal and Insects.

→ Reduce weight so transportation cost is also reduced.

→ Use as a ~~fuel~~ fuel.

METHODS OF SEASONING

NATURAL SEASONING

1. AIR SEASONING

ARTIFITIAL SEASONING

A. BOILING
B. CHEMICAL SEASONING
C. ELECTRICAL SEASONING
D. KILN SEASONING
E. WATER SEASONING.

** NATURAL SEASONING :-

1. AIR SEASONING :-

→ Rate of drying is slow. More time required to dry. (6 month to 2 year)

→ Environment condition not in control.

→ It reduce the moisture content of wood upto 12 - 15%.

→ It make timber tough, durable and elastic.

** ARTIFITIAL SEASONING :-

A: BOILING SEASONING :-

→ It is very quick method. take 3 - 4 hours for removing of sap.

→ Shrinkage is reduce, but strength and elasticity is reduce.

B: CHEMICAL SEASONING :-

→ Timber is immersed in salt solution (i.e. NaCl, $Al_2(SO_4)_3$ etc) (evaporation rate)

→ The time required is 30 to 40 days.

→ The seasoning is done mean by osmos osmosis process.

→ After canical seasoning the timber is placed on Atmosphere Air. for 2-3 days.

→ No shrinkage. happen

ELECTRICAL SEASONING :-

→ High frequency AC is passed across timber. (since timber is a bad conductor of electricity hence it produced high heat and the heat is burn the sap of timber)

* The time required is 5' - 8 hours.

+ It is the most rapid method.

D. KILN SEASONING :-

+ Drying is carried out in a airtaight Chember.

+ fully seturated air is passed through the Champer. the temperature is mantain @ 35 - 38°c which privent evaporation.

→ Strength & dimentional stability is increased

→ Less liable to attack of insect or fungi.

E. WATER SEASONING :-

→ The timber piece partially immersed in running water which washes the all the sap of timber.

→ Timber is taken out after a period of about 2 to 4 weeks.

3. PRESERVATION OF TIMBER :-

→ It is done to increase the life of timber

→ Make durable, and it should allow decorative paints,

→ To protect it from fungai, insects, etc.

→ Inflamable, cheap,

→ It doesnot increase strength and doesnot remove moisture.

Type Of Preservatives :- Code - IS 399

1. ACu Treatment :-

* Composition

I part of Arsenic pentoxide + 2 part of copper sulphate + 4 parts of potassium dichromate.

$As_2O_5 + CuSO_4 + K_2Cr_2O_7$

1 : 3 : 4

6 part of solution + 100 parts of (H_2O) | 6 : 100

→ This solution is used to protect from white ants.

2. Chemical Salts :-

Example :- $CuSO_4$, NaF

* Salt solution is applied on timber surface.

3. Coal Tar :-

→ Timber surface cated with Coal tar.

→ fair resistant

→ unpleasant smell

→ unsuitable for painting.

4. Creosote Oil :- (Bethel's Process)

→ It is tar oil type (distillation of tar).

→ It work as an antiseptic and poisonous for wood attacking fungi.

→ Highly unpleasant smell.

5. Oil Paints :-

→ 2 to 3 coat of oil paint are applied.

→ Preserve from moisture and make it durable.

6. SOLIGNON PAINTS :-

→ Mixed with colour pigments and applied in hot state with brush.

→ Preserve from white ants and are highly toxic.

7. FAIR RESISTANCE :-

a) Special chemical :-

→ Ammonium Sulphate soaking.
→ Zinc Chloride
→ Boric Acid
→ Sodium Silicate.
→ Borax

* Treated with antipyrine containing salts of ammonia or boric or phosphoric acids.

b) Sir Abel's process :-

→ Weak solution of sodium silicate (2 coats) + slaked lime brush solution.

METHOD OF PRESERVATION :-

Code → IS 401

1) Surface Application :- Brushing, Deeping (short time), Spraying.

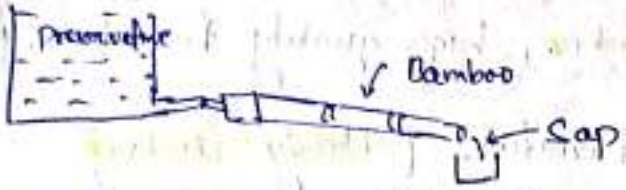
2) Soaking → Debarking + Submerged in preservatives. (long time)

3. Hot and Cold Process :- temp → (80°-90°C)

Timber submerged in preservative → Heat upto 90°C (for air removing)

→ Cool.

4. Boucherie Process :-



5. Pressure / Pneumatic Process :-

a) Futo cell process / Bethel process :- Apply Vaccume pressure + Preservative + Apply Antiseptic pressure

b) Empty cell process → Lowry process → Pres + Antiseptic pressure.
→ Reaping process → Air pressure + Pres + Antiseptic pressure.

7. Charring :-

→ Timber is burnt upto a depth of 10mm. It is a old process.

Advantage :- Prevent from white ant, fungi, insects

Disadvantage :- Loss of strength.

* WOOD PRODUCT :-

1) Veneers → sheet of wood.

2) Plywood Board → Addition of veneers.
→ no. of veneers is odd. (3, 5, 7) etc)
→ no of veneers alternately placed and glued together under pressure.
→ Casein Glue is used to manufacture of plywood. water soluble in colour and obtain from milk.

INTRODUCTION :-

→ Man has used brick for building purpose for thousands of year. Bricks date back to 7000 BC.

→ The artificial material of construction in form of clay brick of uniform size & shape are known as brick.

→ Standard size of modular brick :— 19 × 9 × 9 cm.

→ Size of nominal size (with mortar) :— 20 × 10 × 10 cm.

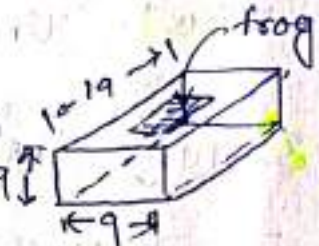
→ Weight of brick :— 3 to 3.5 kg. (standard)

→ Density of brick :— 1800 – 1810 kg/m³ or (1600 – 1920 kg/m²)

→ frog :- i) Size [10 × 4 × 1] mm.cm

ii) Manufacturer name.

iii) Act as shear key between 2 brick so the lateral strength will increase.



two coats of mortar 10 – 12 mm.

→ Size of conventional / traditional brick { 9" × 4.5" × 3" inch (23 × 11.4 × 7.6 cm³ ~~23 × 13 × 8.5~~ 230 × 125 × 86 cm²

↳ conventional (with mortar)

→ E_{brick} : 5 – 7.5 × 10^3 N/mm²

[1cm depth, 1cm width, frog]

CLASSIFICATION OF BRICK :-

1. FIRST CLASS BRICK :-

→ It is table moulded & burned in Kilns (well burnt).

→ Deep red, cherry colour

→ It should have uniform appearence & texture.

→ Smooth, Rectangular, parallel and sharp edges.

→ Should not break when dropped from a height of 1 to 2 m

→ Metallic & clinging sound when struck with each other.

→ Water absorption = 12 – 15 % of its dry weight.

→ It absorption shall not exceed 20% when immersed in water for 24 hrs.

→ Crushing Strength ≥ ~~10 N/mm²~~ 10.5 N/mm²

→ Uses :- for construction of exterior walls, flooring etc.

2. SECOND CLASS BRICK :-

→ It is ground moulded & burned in kiln (well burnt).
→ Rectangular but slight irregularity is permitted.
→ Surface may be slightly uneven.
→ Metallic & clinging sound when struck with each other
→ Crushing strength → 7 N/mm².
→ Water absorption = 16 – 20% of its dry weight.
→ It absorption shall not be exceed 22% when immersed in water for 24 hours.
* Use :- Unimportant hidden masonary work & RCC work.

3. THIRD CLASS BRICKS :-

→ It is ground moulded & burned in clamps.
→ It may be poorly burnt, overburnt or underburnt.
→ Soft and reddish.
→ Rough surface, irregular and distorted edges.
→ Produce dull sound when struck with each other.
→ Water absorption = 22 to 25%. of its dry weight.
→ Crushing strength ≥ 5 N/mm² or (3.5 – 7 N/mm²).
→ W.A. 22% after 24 hr of submerging in water.

4. FOURTH CLASS BRICK (JHAMA BRICKS)

→ These are Overburnt hence dark colour.
→ Badly Distorted shape & size.
→ Brittle in nature.

Use :- Foundation work.

Note:- Comparison

IMP

Properties / Brick Class	1st	2nd	3rd	4th
1) Shape	Even	Slightly uneven	Uneven	Uneven.
2) Crushing Strength	≥ 10.5	≥ 7	≥ 5	< 5
3) Water absorption	20%	22%	25%	> 25%
4) Sound	Clanging	Clanging (Less)	Dull	dull.
5) Colour	Deep Red Cherry	Red	Red-brown/ Blackish	
6) Moulding	Table	Ground.	Ground	
7) Method of Burning	Kiln	Kiln	Clamp	

Note:-

CLASSIFICATION OF BRICKS ON THE BASIS OF STRENGTH:-

IS 1077

Class	Avg comp. Strength.
35	≥ 35
30	≥ 30
25	≥ 25
20	≥ 20
17.5	≥ 17.5
15	≥ 15
12.5	≥ 12.5
10	≥ 10
7.5	≥ 7.5
5	≥ 5
3.5	≥ 3.5

Note:-

Minimum Compressive Strength of brick is 3.5 Mpa

$1\ N/mm^2 = 10\ kg/cm^2$

** COMPOSITION OF GOOD BRICK EARTH :-

SALIM

- Silica (50-60%)
- Alumina (20-30%) } 80-85%.
- Lime (5-10%)
- Oxide of iron / Iron oxide (<4%)
- Magnesia (<1%)
- Alkalies (<10%)
- CO_2
- SO_2
- H_2O

<20%.

* FUNCTION OF COMPOUNDS :- (SALIM)

1. SILICA :-
   - → Percentage – 50-60%.
   - → function :– Absorbs water & provides durability
   - → It prevents cracking, shrinkage, warping of raw brick
   - → It reduces shrinkage during burning.
   - → Excess :- Destroys cohesion between particals of bricks becomes brittles / weak in nature.
   - → It enable brick to retain its shape and size.

2. ALUMINA :-
   - → Percentage :– 20-30%
   - → function :→ Provide plasticity & helping in moulding
   - → Excess :– Causes cracking & warping on drying & burning.

Note :-

Clay
- → Low Alumina ⇒ Low Melting point
- → high Alumina ⇒ High Melting point. ↓ refractory (Heat resistant)

3. LIME :-

→ Percentage - 20 < 10% < 10%.

→ function :- prevent shrinkage on drying, fusion.

→ Excess :- Causes brick to melt & hence brick losses its shape.

4. IRON OXIDE :-

→ Percentage :- < 7%

→ function :- Improves impermeability & durability, red colour

→ Excess :- Causes shrink cracking & warping on drying.

5. MAGNESIA :-

→ Percentage :- < 1%.

→ function :- Imparts yellow tint & reduce shrinkage.

→ Excess :- Causes cracking & warping on drying.

PROPERTIES OF GOOD BRICK :-

- Size & shape :- Smooth Smooth, rectangular, parallel, straight & sharp edges.
- Colour :- Uniform deep cherry red colour.
- Texture :- Rough (so the mortar stick properly)
- Hardness :- When scratched with finger nail it should not make any impression.
- Soundness :- Metallic and clanging sound when struck with each other
- Water absorption :- Not more than 20% of its dry weight when it is immersed in cold water for 24 hour.
- Crushing Strength :- ≥ 10 N/mm. or 10.5 ~~N/mm~~ N/mm.
- Brick earth should be free from stone, grits etc.

MANUFACTURING OF BRICK :-

PREPARATION OF CLAY (BRICK EARTH)
↓
MOULDING
↓
DRYING
↓
BURNING

Step 1: PREPARATION OF CLAY (BRICK EARTH)

* UNSOILING :- Removal of top layer of soil of about 200mm depth.
* DIGGING :- Clay is dug out & spread out.
* CLEANING :- Screening is done to make it free from stone, pebbles, vegitable matters etc.
* WEATHERING :- Clay is exposed to atmosphere for softening.
* BLENDING :- Clay is ~~loosed~~ loosened & ingraidents are spread over it & dry vertical mixing is done. (Dry powder)
* TEMPERING :- Clay is add with sufficent quantity of water & mixed under pressure to make it ready for moulding.

Kneading → Mixing under pressure

Note:- * Method of tempering

manual

Puggying (tempering by using pugmill)

Note

Unsoiling → Digging → Cleaning → weathring → Blending → tampering / Kneading.

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Note:- * Method of tempering

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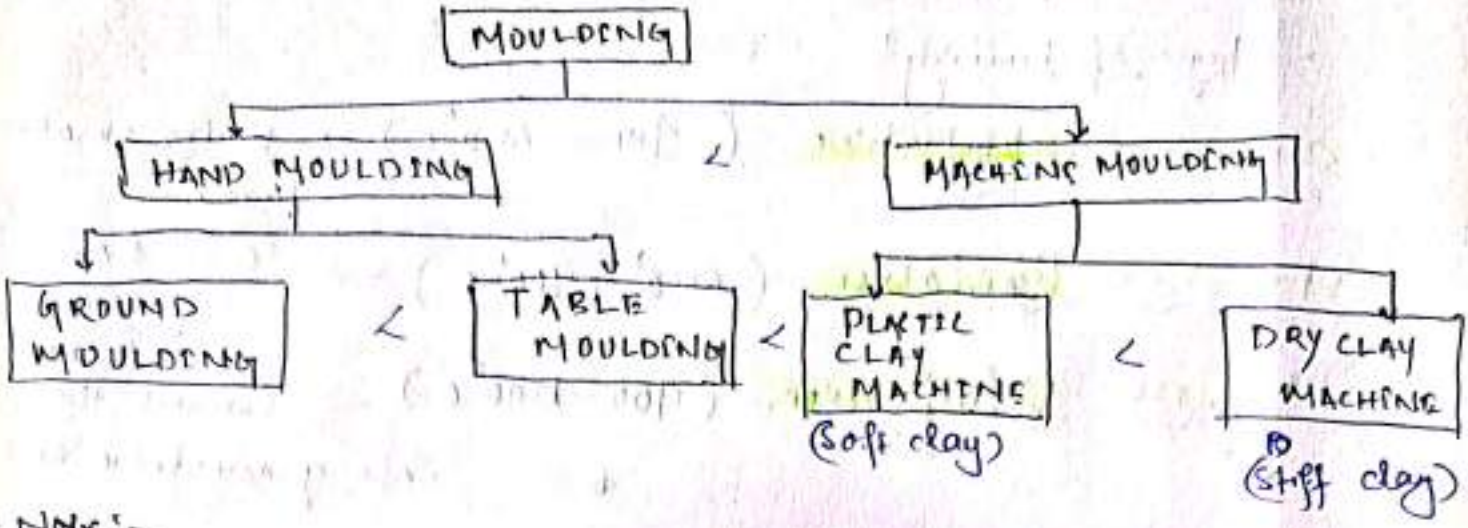
- Pugging (tempering by using pugmill)

Note:

Unsoiling → Digging → Cleaning → Weathering → Blending → tempering / Kneading.

Step-2 : MOULDING :-

→ Process of giving required shape to plastic clay.



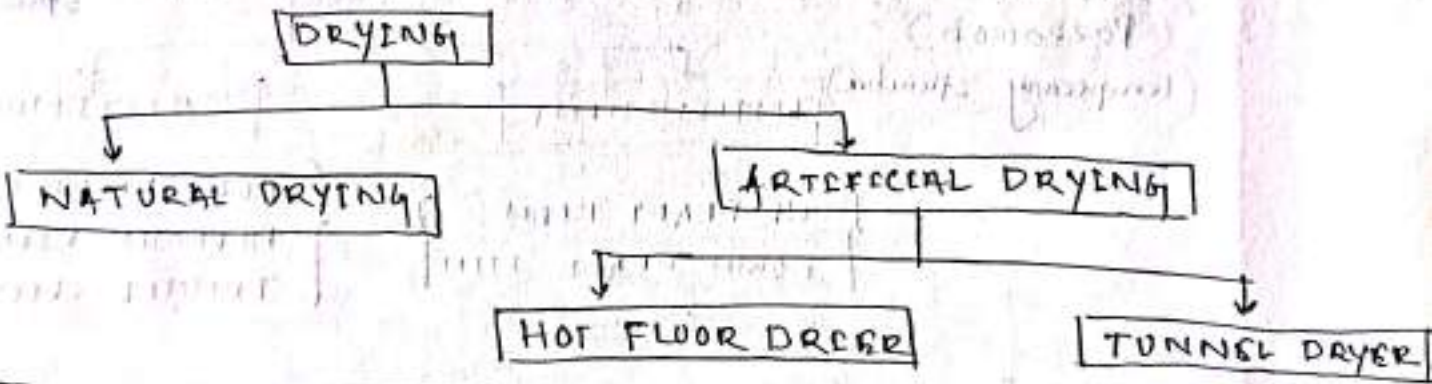
* Note :-

→ Volume of mould is 8 – 12% more than volume.

→ Type of mould [wood / steel]

Step-3 : DRYING :-

→ The Green bricks contain high moisture content & if burnt directly, it is likely to be crack & distorted.



** 30% ~~on drying~~ → 3 – 5% → Removal of moisture content.

Natural drying :-

Stage-1 → Layed by bed (2-3 day)

Stage-2 → Layed by opposite side of bed (2-3 day)

Stage-3 → Stacking of brick (1 week)

STEP-4 : BURNING :-

→ Provides strength & hardness to brick & makes them dance & durable.

- Stages of burning :-

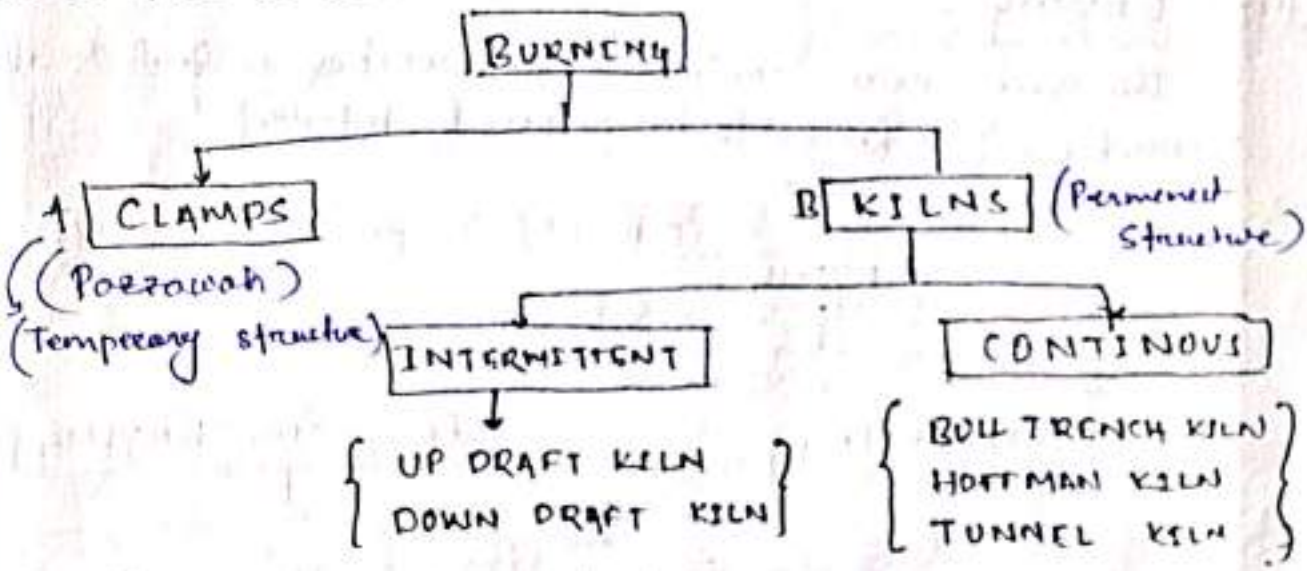
Step-1 → Dehydration (400 – 650°C) → Water evaporating stage.

Step-2 → Oxidation (650° – 900°C) → $C \rightarrow CO_2$, $S \rightarrow SO_2$, $Fe^{3+} \rightarrow Fe^{2+}$

Step-3 → Vitrification (900 – 1300°C) → Convert the mass into grass like substance.

Note :-
{ Low melting point clay (900 – 1100°C) Alumina (↓)
High M.P. clay (1100 – 1350°C) Alumina (↑) }

- METHODS OF BURNING :-



A: CLAMPS :-

→ Small scale manufacturing

Angle = 15°

→ total weight = 3 to 4 m.

→ trapizadal in shape.

→ Period = 1 to 2 months.

→ fuel thickness = 70 to 80 cm.

B. KILNS :-

I.a) INTERMITTENT UPDRAUGHT KILNS :-

→ Laying - thickness - 2 to 3 bricks.
→ Height - 6 to 8 bricks.
→ Arch like opening
→ Loading
→ End closure → Dry Brick + Mud.
→ Fired
→ Firing → 48 to 60 hours.
→ Draught rise upward
→ Cooling - 7 day
→ Dis advantage → Not uniform burning

I.b) INTERMITTENT DOWNWORD KILNS :-

→ Rectangular or Circular in shape.
→ Closed roof
→ Floor of Kiln → Chimney stack
→ Hot gases move downward by chimney draught.
→ Evenly Burnt
→ Better than updraught

II. a: BULL TRANCH KILN :-

Bull tranch Kiln	Hoffman Kiln
) 1 lakh bricks in 12 day	→ 40 lakh in a seaso
) Initial cost is Low	→ Initial cost high.
% of good quality brick is Less	→ is more
High fuel consumption	→ Low fuel consumption.
Required More space	→ Requir Less Space
Not popular	→ Less popular
Temporary Roof. (It stops functioning during monsoon season)	→ Permanent roof (functoning through the year)

TESTING ~~for~~ Of BRICK

1. DIMENSION TEST :- IS 1077

- Dimension of brick is tested by stacking 20 brick.

:-

For Modular bricks

Length 3720 to 3880 mm (3800 ± 80 mm)

Width 1760 to 1840 mm (1800 ± 80 mm)

height 1760 to 1840 mm (1800 ± 80 mm)

(For 90 mm high brick)

COMPRESSIVE STRENGH TEST :-

IS 3495 - Part 1

Brick immersed in water (24 hr) → frog can fill with (Cement Sand Mortar) 1:3 → Brick (immersed in water for 3day) → @ 14 N/mm²/min (Loading rate) → Compressive strength.

Compressive Strength in N/mm² —

$$\frac{kgf}{cm^2} = \frac{\text{Maximum Load at failure in N (kgf)}}{\text{Average area of 2 faces under compression in } mm^2 (cm^2)}$$

WATER ABSORPTION TEST :—

IS 3495 - Part 3

Dry Bricks → oven 105°-115°C → (Constant Mass) (W_1) → 24 Hr Cold water, Temp → 27° ± 2°C → Saturated brick (W_2)

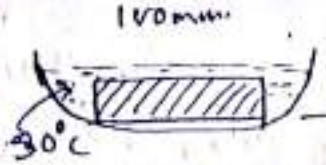
24 hour Water immersion test.

$$\text{Water Absorption} = \frac{W_2 - W_1}{W_1} \times 100$$

Water absorption should not be grater than 20%

EFFLORESCENCE TEST :—

IS 3495 - Part-3



Keep it until entair H_2O evaporates.

Classification Catagory :—

Nil :— (0%) When there is no perceptable deposite of efflorescence

Slight :— When not more then 10% of the exposed of the

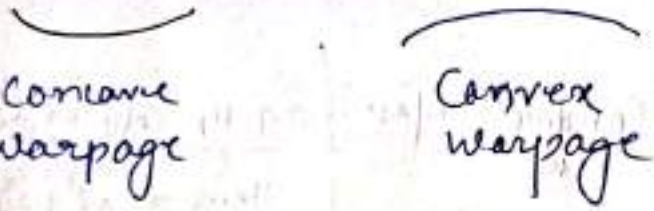
c) Moderate :- when there is a heavier deposit than 'slight' and covering up to 50% of the exposed (10-50%)

d) Heavy :- (>50%)

e) Efflorescence :- when there is a heavy deposit of co accompaind by powdering and/or flaking of t exposed surface.

5. WARPAGE TEST :-

IS 3495 - Part 4



Concave warpage

Convex warpage.

*** DEFECT OF BRICK :-

1) OVER BURNING :- brick loses shape, color is black

2) UNDER BURNING :- Pores are not closed hence weak. Looks like yellow in color.

3) BLOATING :- By spongy swollen mass due to ex Sulpher.

4) BLACK CORE :- Bituminous matter or ca present in brick.

5) EFFLORESCENCE :- White patches due to the alkalies Leaching Out.

6) CHUFFS :- Deformation occurs if rain water falls on hot brick.

CHECKS :- Lumps of lime cause volume change by absorbing moisture.

SPOTS :- Due to sulphides, dark surface spots on surface.

BLISTERS :- Due to trapping of air

LAMINATIONS :- Entrapped air in voids of clay form form thin laminar on surface.

BRICK MASONRY

BRICK → Building units of Masonry

MORTAR → Building the building unit & providing strength to act as a single unit

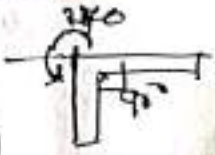
BRICK MASONRY :- Construction of building unit join bonded together with mortar.

xxx

Note :-
Provision of Lap → Bonded wall
Lap not provided → Unbonded wall

TERMINOLOGY :-

- Stretcher :- Long face (19 × 9) of brick
- Header :- Shorter face (9×9) of brick
- Lap :- Horizontal distance b/w vertical joint of adjacent courses.
- Perpend :- Immaginary vertical line including vertical joint of alternate courses.
- Arris :- Edge of brick
- Bed :- Bottom Surface of brick when laid flat.
- Quoin :- Corner of masonry wall.
(exterior Corner angle of masonry)



8. Closer :- When bricks are cut along the length.
9. Bat :- When bricks are cut along the width.

BOND :-

Lapping of bricks to enhance interlocking.

Note
facing → Front face
Backing → Back face
Heading → middle

TYPE OF BOND

1. HEADER BOND :-

- 1 brick thick (around 20cm)
- → 1/4 th bat is used to overlap & maintain perpend.

Lap = 1/4 th of Lapse of brick

2. STRETCHER BOND :-

- → 1/2 brick thick wall
- → 1/2 bat is used to overlap & maintain perpend.

USES :- Pathway wall / B, Chimney wall.

Note :-

Minimum thickness of load bearing wall is one brick thick.

HEADER BOND strength > Stretcher Bond strength

Rules OF BONDING :-

1) Brick should be uniform size
2) Amount of lap - min 1/4 along along length of brick
   1/2 brick along thickness of wall.
3) Use of brick bat should be avoided but it can be used in special location.
4) Vertical joint in alternate courses should lie along same line.

It is preferable to provide every 6th course as header course.

Types of bond :-

ENGLISH BOND :- (Header & Stretcher is used on alternate layer)
(Most commonly used)

* 1½ brick thick new wall
Queen closers used to overlap & Mantain perpend.
It is strongest Bond.

FLEMISH BOND :- (Pleasent appearance) (header & stretcher is used in same layer)

* 1½ brick thick wall
Queen closer is used to overlap & mantain perpend.

(a) Single Flemish.	(b) Double Flemish.
facing → Flemish	facing → Flemish
Backing → English	Backing → Flemish

* DUTCH BOND :- It is a special type of english bond where 3/4 bat is used as a quoin to main perpend.

RAKING BOND :- Inclined brick are used, which increase stability in lateral direction.

- Diagonal bond
- Herring bond bone bond

ZIG-ZIG bond :-

facing bond :- Bricks of different thickness are used.
~~In proper load distribution~~
→ Load distribution is not uniform.

* SPECIAL TYPE OF BRICK :-

1. HEAVY DUTY BRICK :-

IS 2180

→ It has 2 class [i.e Class 400 → avg. comp. strength 40 N/mm²
Class 450 → " " " 45 N/mm²]

→ Density < 2000 kg/m³

→ Efflorence – Nil.

→ Water absorption ≤ 10%.

→ Tolerence limit of size :-

	Subclass A	Subclass B
19cm	±6 mm	±10 mm
9cm	±3 mm	±7 mm.

Uses :- Bridge, Industrial foundation, multi storied building.

2. BURNT CLAY PERFORATED BRICK :-

IS 2222

→ Area of perforation should not be more than 30 to 45% of the of face area.

→ Area of each perforation should not be more than 500 mm²

Use:

→ Water absorption < 15%.

→ Compressive strength < 7 N/mm²

USE :- Partition wall, Light structure.

3. BURNT CLAY HOLLOW BRICKS :-

IS: 3952

→ Contains Cavity block

→ Reduce transmission of heat & sound.

4: REFRACTORY BRICK / FIRE CLAY BRICK :-

→ Fair clay → (Alumina content, weight) Use → chemistry

→ It can resist a temp. of 1700°C

→ Water absorption = 4-10%.

→ These bricks are burned for longer duration.

→ Alumina, Silica content is increased, lime is decreased

→ 3 Type :- Acid Brick | Basic Brick | & Neutral brick

Acid Brick	Basic Brick	Neutral brick
i) fine brick	1) Magnesite brick	i) Chrome Brick
ii) silica brick	2) Dolomite brick	ii) Chrome-Magnesite Brick
	3) Boxide brick (More refractory)	iii) Spinal Brick
		iv) fosterite Brick

5: Acid ~~Resistant~~ Resistant Brick :-

IS 4860

→ Use → Chemical plant, Chamber lining.

Dimension :- (230 × 114 × 64) cm.

Type [Class I (WA ≯ 2%)
Class II (WA ≯ 4%)

6: Sewer Brick :-

IS 4885

→ Made from fine clay shelter.

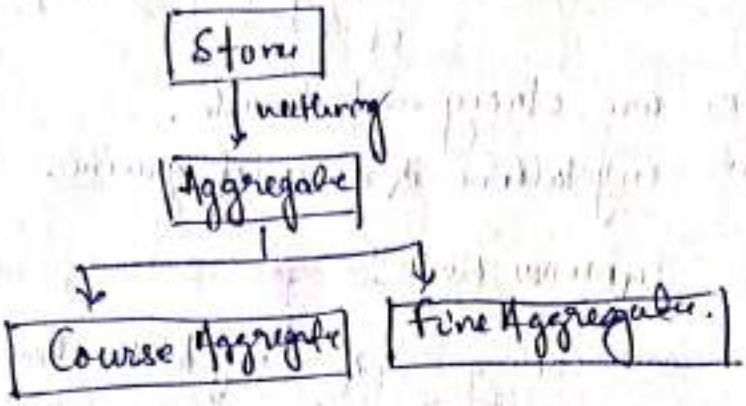
7: Burnt clay Paving Brick :-

IS: 5779

→ use for paving

Ch-6: STONES

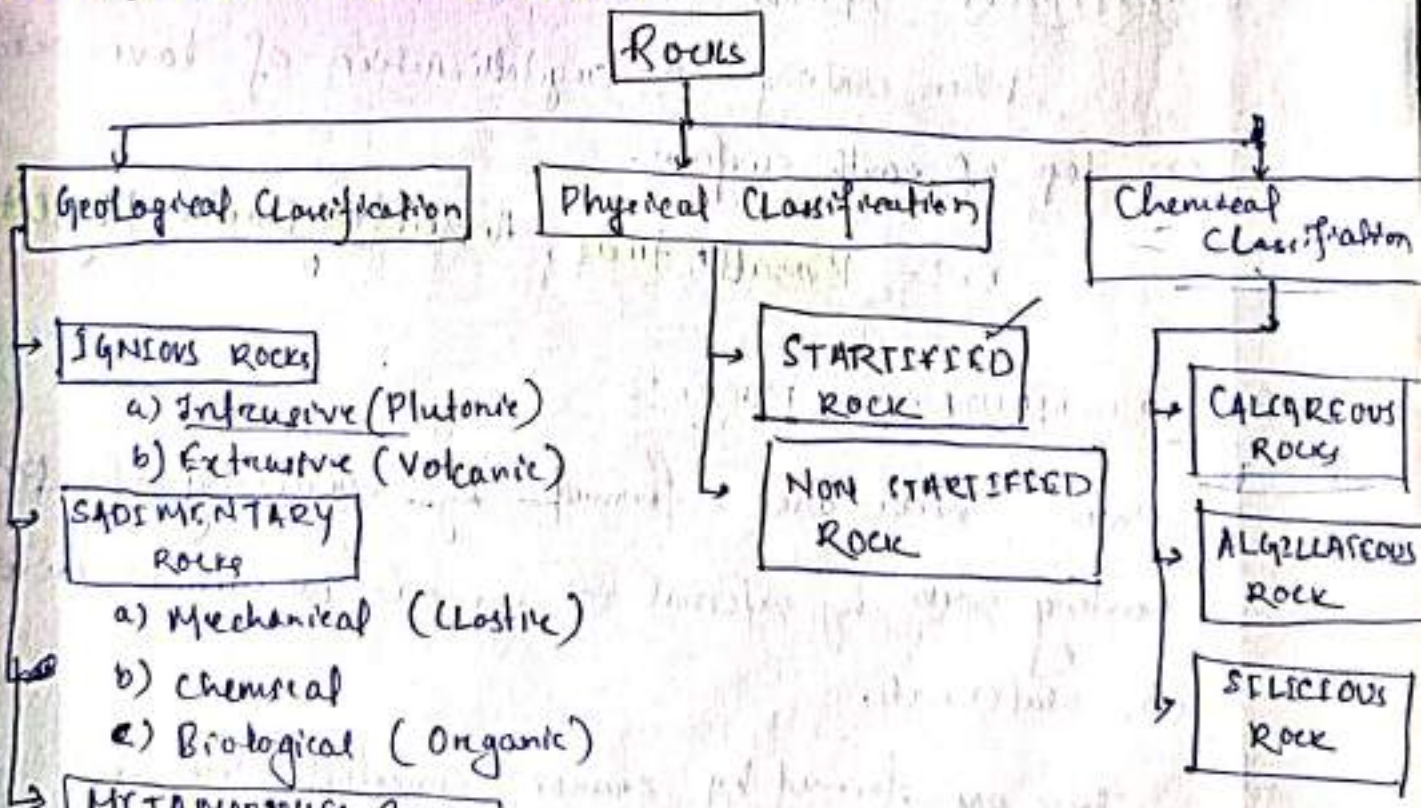
1. INTRODUCTION



→ Stone are naturally occuring compact, solid, & massive materials that make the crust of the ~~earth~~ Earth..

→ Stones are technically rocks which are used since time immemorial.

2. CLASSIFICATIONS OF ROCKS:-



1: GEOLOGICAL CLASSIFICATION OF ROCK:-

A. IGNEOUS ROCK:-

→ Rock formed by cold cooling and solidification of magma or Lava.

→ These rocks are strong and durable.

→ They have crystalline & compact grains.

i) INTRUSIVE IGNEOUS Rock:-

When cold cooling and crystallization of magma occurs deep inside earth surface.

a) Plutonic rock:- When magma cools deep inside earth.

Ex → Granite.

b) Hypobasal rocks:- When magma cools at sallow depth.

Ex:- Gabbro, Q. Diorite, Pegmatite etc.

ii. EXTRUSIVE IGNEOUS ROCK:- (Volcanic Rock)

When cooling and crystallization of lave occurs on top of earth surface.

Ex:- Basalt, trap, Andesite, Dacite, Rhyolite etc.

2. SEDIMENTARY ROCKS:-

→ These rocks are formed by weathering of pre existing rock by external agencies such as wind, air, water, etc.

→ These are formed by consolidation and Sedimentary deposits of rock.

13. NON-FOLIATED ROCKS:-

→ The rocks do not have bands or streaks on their surface or body.

Example:- Quartzite, Marble.

Note:-

Stone	Type	After Metamorphism
GRANITE	→ IGNEOUS (Plutonic Rock)	→ GNEISS
BASALTO	→ IGNEOUS (Volcanic Rock)	→ LATERITE
LIMESTONE	→ SEDIMENTARY	→ MARBLE
MUD STONE	→ SEDIMENTARY	→ SLATE (DPC)
SANDSTONE	→ SEDIMENTARY	→ QUARTZITE

2. PHYSICAL CLASSIFICATION:-

1. STARTIFIED ROCK:-

→ Rock showing layered structure.

Example:- sandstone, lime stone, shale

B. UNSTARTIFIED ROCK:-

→ Rock not showing Layard structure (cannot be easily split in slices.)

→ Example:- Granite, Trap, Marble, Quartzite. etc.

Note:

Startified → Sedimentary
Unstartified → Igneous, Metamorphic
Foliated / Non foliated → Metamorphic

CHEMICAL CLASSIFICATIONS :-

A. CALCAREOUS ROCK :- Main Comp. Component = Calcium Carbonate.

Ex → Marble, Limestone.

B. SILICEOUS ROCK :- Main Component = Silica

Eg → ~~Slate, clay, Mudstone, Laterite~~ Sandstone, trap, Quartz, Granite.

C. ARGILLACEOUS ROCK :- Main Component = clay & alumina.

Ex → ~~Sandstone, Trap, Quartz, Granite~~ slate, clay, Mudstone, Laterite

Note :-

Stone	Geological	Physical	Chemical.
Granite	Igneous	Unstratified	Siliceous
Sandstone	Sedimentary	Stratified	Siliceous.
Limestone	Sedimentary	Stratified	Calcareous
Marble	Metamorphic	Non-foliated	Calcareous
Quartzite	Metamorphic	Non-foliated	Siliceous
Slate	Metamorphic	foliated	Argillaceous

clay & Alumina → Mudstone Metamorfied by form.

* PHYSICAL PROPERTIES Or ✂ STONE :-

1. Hardness :- It depends on mineral composition.
2. Cleavage :- Measure of capability of some minerals to split along certain parallel to crystal surfaces
3. Streak :- Colour of mineral in powder form.
4. Colour :- Metallic minerals colour are more predictable non-metallic minerals colour are less predictable.
5. Lustre :- Shine on a surface. and its appearance under reflected light.
6. Crystal :-

* MINERALS :-

→ MOH'S HARDNESS SCALE :-

1	Talc (thumb nail)
2	Gypsum (thumb Nail)
3	Calcite (knife)
4	Fluorite (knife) → different
5	Apatite (knife) → very difficult.
6	Orthoclase (knife) (on the thin edges)
7	Quartz
8	Topaz
9	Corundum.
10	Diamond (Hardest mineral)

TYPES :-

1. MONOMINERAL ROCK :- Rock bearing One mineral

Eg :- Gypsum.

2. Polymineral Rock! - Rock having more than one minerals.
Eg → Granite, Basalt etc.

Note! - Marble has Calcite minerals.
Granite has Quartzite & feldspar.

Note! -
1. Minerals ha Highest weathering resistance → Quartz - Quartzite.
2. Least water absorption → Slate
Use → roofing Material
DPC

** ✓ Characteristics Of Good Building Stone! -

1. Good in appearence.
2. Well seasoned Stone - (to remove moisture & stone can be air dried upto 6 to 12 month) to certain Limit.
3. Water absorption → Not more than 5%. (✗)

Note! - Stone whose water absorption > 10% is rejected as building stone.

4. Easily workable, dressable.
5. Weathering resistance.
6. Fire resistance.
7. Hardness (Resistance to abrasion / Scratch resistance)
8. Toughness (Resistance to impact)
9. Crushing strength (> 100 mpa)

Note! -

	W.A	Crushing strength
Brick	<20%	>10 mpa
Stone	<5%	>100 mpa

iv. Specific Gravity – > 2.7 [2.5 – 3]

v. Porosity → It should be less porous → Water absorption less, weight more

TESTING OF STONES :-

1. SMITH TEST :-

→ To determine presence of soluble matter in stone.

Procedure :-

Stone → clean water → Clean water (No – soluble matter)
→ Turned water (soluble matter)

2. CRUSHING TEST :-

→ 3 cube of 40 mm are taken & average is reported.

Procedure

40 mm stone cube → 3 day (72 hour) (3 day) submerged with water → 5 mm thick putty or plywood → CTM / UTM @ 14 N/mm²/min.

Igneous	Trap	330 MPa
	Basalt	150 – 180 mpa
	Granite	70 – 120 mpa
Sedimentary	Limestone	50 mpa
	Sand stone	60 mpa
	Shale Slate	0.1 – 0.6 mpa
Metamorphic	Gneiss	200 – 370 mpa
	Shale	75 – 200 mpa

Note :- Compressive Strength → Crushing Strength

Compressive Strength → SIM

Sedimentary < Igneous < Metamorphic

3. ATTRITION & TEST :- (Wear & tear Measure)

→ It is done in Deval testing machine. (DTM)

→ 60 mm size stones are taken & rotated for 5 hours @ 30 rpm.

$$\text{Rate of wear} = \frac{\text{\% age of weight passing 1.7 mm sieve}}{\text{Wt. of sample}} \times 100$$

Note :-

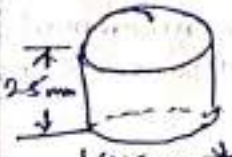
- Rate of wear < 3% → Good Quality
- Rate of wear = 3% → Medium (Tolerable)
- Rate of wear > 3% → Bad & can't be used in stone masonry

4. HARDNESS TEST :-

→ It is done in Dorry testing Machine.

→ Hardness mean Scratch resistance / Abrasion resistance.

Procedure



Subject to → [P = 12.5 KN @ 28 rpm for 1000 revolution]

Measure the Loss in weight -

$$\text{Loss in Weight} \propto \frac{1}{\text{Hardness}}$$

$$\text{Co-efficient of hardness} = 20 - \frac{\text{Loss in weight}}{3}$$

Note :-

- Co-efficient of hardness < 14 → (Poor hardness)
- Co-efficient of hardness → 14 - 17 → (Medium hardness)
- Co-efficient of hardness → > 17 → (Very hard)

5. IMPACT TEST :-

→ This is done using impact testing machine.

→ In this 20 to 30 mm cylindrical aggregate is impacted by a hammer of mass 2 kg & allowed to fall from different heights until the specimen fails.

→ **Toughness Co-efficient = Height in Cm from which specimen fails**

* Note :-

- Co-efficient of toughness < 13 → Poor toughness.
- Co-efficient of toughness 13-19 → Moderate toughness.
- Co-efficient of hardness > 19 → Very tough stone

6. ACID TEST :-

→ It is used to determine the weathering resistance capacity

Procedure :-

Stone (with sharp edges) — dipped in HCL in 7 day. →

- Surface Power (Sharp edges are decomposed) → Weathering resistance is Less.
- Surface are not converted in to power form. (Sharp Edges Surface) → Weathering resistance more.

7. CRYSTALLISE TEST & ~~BRARDT TEST~~ :- BEARD'S TEST :-

→ It is used to determine the absorbility.

8. SPECIFIC GRAVITY :-

→ It is the range, 2.1 to 3.

⇒ for good stone, it is greater than 2.7 → weight ↑ → stability ↑
→ Less pores → Water absorption ↓
↳ Density

9. Brad' TEST :-

→ It measures thrust resistance.

(Thrust Resistance)

** STONE MINING PROCESS :-

1. QUARRYING :-

→ It is a multistage process by which rock is extracted from ground and crushed to produce aggregate.

→ Rough dressing with spalling hammer immediately after Quarrying because it is soft.

2. SEASONING :-

All freshly quarried stones contain a certain amount of moisture known as quarry sap, which make them soft. soft and easier to work upon. Good stone should be free from quarry sap.

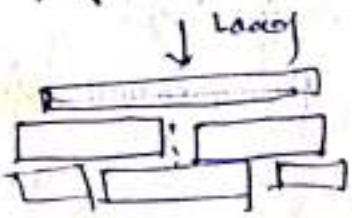
3. DRESSING :-

⇒ Stones obtain from quarring have rough surface.

→ Dressing is the process of cutting the stones into regular shape and size with the required finish surface.

* Perpare :-
→ Suitable size
→ Regular shap and pleasing appearience.
→ Perper bedding for stone masonary.

Note :-
* Load chand always be applied perpendicular to natural bading of stone.



Note :-
* USES OF STONE :-
* Abutment of piere → Granite
* facing work → Granite, Marble
* Kankar → Hydraulic Lime
* Flooring → Lime stone, Marble, Sandstone
* Paving Work → Gneiss
* Ballast & foundation → Basalt, Trap and Granite, Quartzite.
* D.P.C & Roofing Material → Slate.
* Manufacturing of Putty → Chalk.

* Important topics :-
* SELECTION OF QUARRYING SITE :-
We have to keep following factors into consideration while deciding about the location of a quarry site.
→ Availability of Sufficient quantity of the stone of desired quality.
→ Proper transportation facilities.

Quarrying is done by 4 different methods. these are

i) Excavating
ii) Wedging
iii) Heating
iv) blasting

i) Excavating :- Stones buried in earth or under loose overburden are excavated with pick axes, crow bars, Chisels, hammer etc.

ii) Wedging :-

→ Mainly used for Sedimentary rocks.

→ This method of quarrying is suitable for costly, soft and stratified rock such as sandstone, limestone, Laterite, marble and slate

→ About 10-15 cm deep hole, at a round 10 cm spacing, are made vertically in the rocks.

→ Steel pin and wedges are plugs (Conical wedges) and feathers are inserted in them.

→ The rock slab splits along the line of least resistance through holes.

→ The slab is completely detached and taken out with the help of crow bar and rollers.

→ If is the method the wastage is minimum and slabs of required size and shape can be carried.

(iii) Heating :-

→ Heating is the most suitable for quarrying small, thin and regular blocks of stones from rocks, such as granite and gneiss.

→ A heap of faggot fuel is partly and fired on the surface of rock in small area.

→ The two consecutive layer of rock seperate because of uneven expansion of two layer.

→ The loosened rock portions are broken into pieces of desired size and are removed with the help of pick-axes and crow-bars.

(iv) Blasting :- Mainly used for tough rock like Igneous, Metamorphic rocks.

* Explosive used are :-

→ Blasting Powder. - (75% salt petre + 10% Sulphur + 15% Charcole)
→ Blasting Cotton / Gun Cotton
→ Dynamite
→ Cordite.

* Operation Involved are :-

→ Boring
→ Charging
→ Tamping
→ Firing.

Process :-

→ Holes are drilled or bored in the rock to be discharged. for vertical holes, jumpers is used, where as for inclined or horizontal holes, boring bars are used.

→ One person holds the jumper exactly in the face places where hole is to be made, the other person strikes it up and down and rotates it simultaneously.

→ Water is poured in the hole regularly during the operation to soften the rock and facilitate drilling.

→ The muddy paste generated in the process is removed from holes by scrapping.

→ For hard rocks, machine drilling is employed instead of hand drillers.

→ The holes are dryed completely and the required amount of charge is placed in the holes.

→ For drying the holes, rag of tied in the scrapper and is moved in the hole from where it absorbs the moisture, if any.

→ In case if it is found the water is coming into the holes, water tightness is ensured inside the holes

→ After placing the charge in the hole, a greased priming needle, projecting a little outside the hole is placed in the holes which is then filled up with damp clay or stone dust in layers tamped sufficiently with a barred tamping rod.

→ The priming needle should kept on rotating while tamping is going on.

→ This is done so that the needle remains loose in the hole
→ The priming needle is then taken out and 60 to 75% percentage of space created by withdrawal of needle is filled with Gun powder.

A Bickford fuse, a small rope of cotton coated with tar, is placed just touching the needle.

The other end of fuse is kept of sufficient length so that the person igniting it can move away to a safe place.

Blasting:-

The blasting powder and candite are ignited by means of a fuse, where gun cotton and dynamite are exploded by detonation.

Note :- (N. imp) (to remember)

* Methods of rock Quarrying :-

i) Wedging → Sedimentary rock

ii) Blasting → Igneous Rock & Metamorphic Rock

iii) Excavating →

iv) Heating →

* Explosives :—

i) Blasting powder → { 65-75% Saltpetre (KNO3)
+ 10% Sulphur
+ 15% of charcoal.

ii) Gun Cotton / Nitrocellulose

iii) Cordite → Nitroglycerine

iv) Dynamite → { 75% Nitroglycerine absorbed in
25% Sandy earth.

* Seasoning will carried out for 6 month to 12 month.

*

Stone Masonry

- Rubble Masonry
  - Random Rubble Masonry
  - Polygonal Rubble Masonry
  - Flint Rubble Masonry
  - Dry Rubble masonry (
- Ashlar Masonry
  - Ashlar fine
  - Ashlar Rough
  - Ashlar chamfered
  - Ashlar Block.

STONE MASONARY :-

1) Rubble Masonary
2) Ashlar Masonary

mparision

Rubble Masonary	Ashlar Masonary
• Irregular shape of stone are used.	→ Regular shape of stone are used
→ Rough dressing in masonary	→ Smooth dressing in masonary
→ Wide joints.	→ fine joint of 3mm.

PRESERVATION OF STONE! -

→ Stone is dried with blow lamp

i) Temporary prevention → Coating of parrafin, linseed oil, light paint.

ii) Permenent preservation → Baricum Hydrate.
(CBARYTA)
→ $Ba(OH)_2$

CH-7 : MORTAR

→ It is consist of a binding material & fine aggregate.

Dry Mortar

Mortar → Binding Material + fine Aggregate + ~~fine aggre~~ Water

↓ Cement, Lime, Gypsum,

↓ Sand & Surkhi

Volume of Dry Mortar = ~~1.33~~ 1.25 of volume of ~~Dry Mortar~~ Wet mortar (without wastage)

(Aggregate → 4 different)

→ Property of ~~fine~~ Sand used for Mortar! –

→ It should be chemically inert (non-reactive)

→ Well graded sand

→ free from Organic matters

→ free from Salt that absorption moisture.

→ Purpose of using Sand in Mortar! –

1. Strength → Re adjustment of strength can be done by adjusting proportion of sand.
2. Bulk → Increases volume of mortar hence decreases of cost.
3. Surface Area → Sand increases surface area.
4. Shrinkage! – Reduce tendency of volume change
5. Setting time! – Sand helps in ~~capture~~ escape of gases and leading out for mortar. and hence reduces of cracking.

~~CLASSIFICATION OF BASED ON BINDING MORTAR~~ :-

CLASSIFICATION OF MORTAR :-

1. BASED ON BINDING MATERIAL :-

A. CEMENT MORTAR

B. LIME MORTAR → Setting time ↑, Shrinkage / Cracking ↓, Plasticity (workability) ↑, Cost ↓

C. GYPSUM MORTAR

D. MUD MORTAR

E. ASPHALT MORTAR

F. GAUGED MORTAR → (Cement + Lime) (1:6 to 1:8)

2. BASED ON ADULTRENT / FINE AGGREGATE :-

A. SAND MORTAR

B. SURKHI MORTAR → Surkhi improve hydraulicity.
↓
Ability to set in presence of water or where there is no circulation of air

C. SAND - SURKHI MORTAR

3. BASED OF BULK DENSITY :-

A. HEAVY MORTAR → Bulk Density > 1500 kg/m³ → Heavy Quartz sand used

B. LIGHT MORTAR → < 1500 kg/m³ → Light quartz sand used.

4. BASES OF STRENGTH :-

(Classification)	N/mm² Strength
H_1	> 10
H_2	6.5
M_1	3.6
M_2	2.3
M_3	1.5
L_1	0.7
L_2	0.5

I.S. 1905

5. BASIS OF APPLICATION :-

A. ~~Bottle~~ ~~Lay-up~~ BRICK LAYAR APPLICATION

B. PLASTERING APPLICATION.

6. SPECIAL MORTARS :-

A. FIRE RESISTING MORTAR → Alumina Cement + Fire clay powder + Surkhi.

B. LIGHT WEIGHT MORTAR → Use Light aggregate.

C. PACKING MORTAR → Used in Oil well (Dry well cement + sand)

D. SOUND ABSORBING MORTAR →

E. X-RAY SHIELDING MORTAR → Barium Sulphate.

F. D.P.C MORTAR :-

7. APPLICATION OF MORTARS :-

1. GUNITING :-

→ Application of Mortar or ~~cement~~ Concrete under high pressure through cement Gun. which gives proper bond.

→ Compressive Strength > 40 N/mm²

→ Cement-Sand Ratio → 1 : 3 by weight

2. GROUTING :-

→ Cement Mortar of fluid Consistency is used fill void and joints in masonry or repair the cracks.

Note - V. Imp

Selection of Mortar Proportion

Work	Proportion
1) General RCC work (Colum, wall, lenter)	1 : 3
2) D.P.C & Concrete pavement	1 : 2
3) Internal wall/surface of Less important	1 : 3
4) Perfation / Parapate wall	1 : 3
5) Plastering work	1:3 – 1:6
i) Exterior	1:3 – 1:4
ii) Interior	1:5 – 1:6
6) Pointing work	1:1 – 1:3
7) Rainforced brick work	1 : 3
8) Construction work in water logged areas	1 : 3
9) Ornamental work/ Cavernous work	1 : 1.5

Exam Question

Type of work	cement	Sand
Pointing	1	3
Rainforced brick work	1	3
Guniting	1	3
Masonry	1	4-5
Plastering	1	5-6

PROPERTY OF GOOD MORTAR :—

1. Design strength should be grater then Stresses developed
2. It should Good adhation with building units.
3. Water tight → so that it resist penetration of water.
4. Durable.
5. Cheap
6. Workable.
7. It should inert / Non-reactive.

CH-8 : LIME :-

$CaCO_3$:- Calcium material (Lime stone)

Calcination → (1000 - 1200°C) heating

$CaCO_3 \rightarrow CaO + CO_2 \uparrow$

CaO → Quick lime / Lump Lime

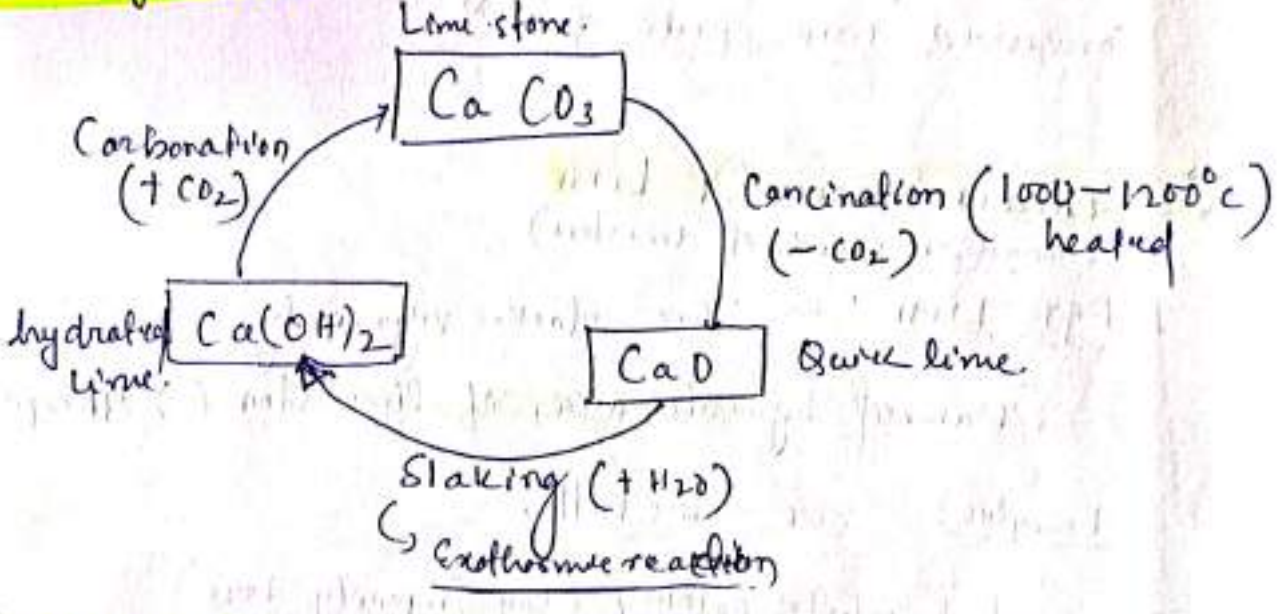
+ water (H_2O) (Slaking)

$CaO + H_2O \rightarrow Ca(OH)_2$ hydrated lime.

$+ CO_2$

$Ca(OH) + CO_2 \rightarrow CaCO_3 + H_2O$

Lime Cycle :-



Terms & Definations :-

1. CALCINATION :-

Heating of lime stone to redness in presence of air.

$$CaCO_3 \xrightarrow[1000-1200^\circ C]{\Delta} CaO + CO_2 \uparrow$$

2. QUICK LIME :-

Lime Obtained by calcination of comparatively pure lime stone. It will also known as Quick lime / Lump lime / Caustic lime. It has high affinity of water.

3. SLAKING :—

When sufficient quantity of water is added to Quick lime reacts vigorously.

$$CaO + H_2O \longrightarrow Ca(OH)_2 + \text{Heat } (15.6 \text{ kcal/gm})$$

↳ Hydrated lime.

4. Hydraulicity :—

It is the property of Lime by which it sets or hardens in presence of water, damp places, no free circulation of air.

5. SETTING :—

The process of hardning of lime after it has been converted into paste form.

CLASSIFICATION Of LIME

(Based on purity of Limestone)

1. FAT LIME :— This slacks vigorously

→ Obtained by calcination of lime stone (> 95%)

→ Examples :- Sea Shells,

* Perfect white colour (Clay impurity Less)

→ It increase its volume by 2 – 2½ time then its original volume. hence known as fat Lime.

→ Use :- Plastering, painting, white washing.

⇒ It is also known as Pure lime, High calcium lime, Rich lime, White lime. etc.

⇒ Soluble in water.

HYDRAULIC LIME :-

- It is known as water lime, because of its ability to set under water.
- It poses hydraulicity
- Obtained from calcination of limestone having purity 70 – 92%.
- Insoluble in water.
- Little dull white colour than fat lime.

USES :- Brick and Stone masonary (Because of hardness or sets faster than fat lime.)

POOR LIME / IMPURE LIME / LEAN LIME :-

It contains more than 30% clay hence slakes slowly but possess hydraulicity

USES :- In foundation.

OTE :-

V.imp

TYPE	LIME STONE		Colour	Scale		
	$CaCO_3$	Impurity		Colour	Hydraulicity	Slacking
Fat lime	> 95%	< 5%	White.	White ↓ brown	Increases ↓	decreases ↓
Hydraulic Lime	70 – 95%	5% – 30%	White + Less brown.			
Poor Lime	< 70%	> 30%	Less white More brown.			

IMPURITIES IN LIMESTONE :—

1. Clay :- It imparts hydraulics properties to lime.

Range → 8 to 30 %

2. $MgCO_3$:— Irregular display of hardning, setting, slaking.
   * → Excellent hydraulic properties.

3. Silica :— It has degrading effect on lime.

4. Iron Compounds :— In hydraulic lime 2–5 % Iron compounds are necessary. But its unfavourable

5. Sulphates :— It slows down slaking action & setting time is necessary of lime.

6. Alkalies :— It is also undesirables.

CH-9: AGGREGATES

Introduction:-

Aggregate is nothing but crushing stone or any other material.

Concrete ← Cement, Sand (Fine Aggregate), Course Aggregate } Aggregates 70 - 80% of volume of concrete occupied by aggregate.

> CLASSIFICATION OF AGGREGATE:-

A. ON THE BASIS OF GEOLOGICAL ORIGIN:-

1. NATURAL AGGREGATE:-

→ Obtained by Crushing of pre existing rock i.e Igneous or Sedimentary & Metamorphic rock

2. ARTIFICIAL AGGRAGATE:-

→ Broken bricks, Blast furnance slag & synthetic aggregate etc.

B. BASED ON SIZE:-

1. COURSE AGGRAGATE:-

The size of 4.75" to 80mm.

2. FINE AGGREGATE:-

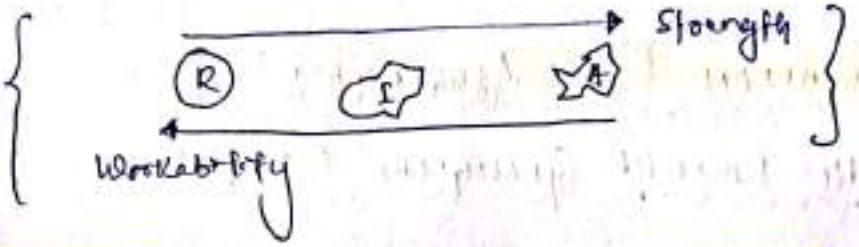
Size → 0.075" - 4.75" mm.
(75μ)

Note:-
Possible smallest size of fine aggregate is 0.06 mm or 60 μ.

C. BASED ON SHAPE :-

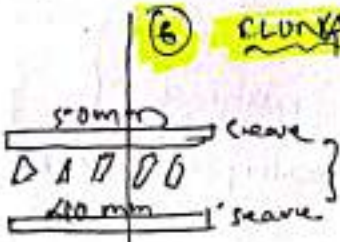
1. ROUNDED :- Voids → 32-30%, Specific Area = Less
   → Less bond strength, No. Interlocking.
   → More lubrication hence high workability.
2. IRREGULAR / PARTLY ROUNDED :- Void → 36%,
   →
3. ANGULAR :- Void → 40%, Surface area = Greater. (38-41)%
   → Better Interlocking
   → Best bond strength.
   → Least lubrication hence least workability

Note



(A) FLAKEY AGG.

(B) ELONGATED AGG.



Mean size = $\frac{40+50}{2}$ = 45mm.

(Flaky) 0.6 × Mean size ← Good Aggregate → 1.8 × Mean size (Elongated)

$\frac{3}{5}^{th}$ of Mean size

$\left(\frac{9}{5}\right)^{th}$ of Mean size.

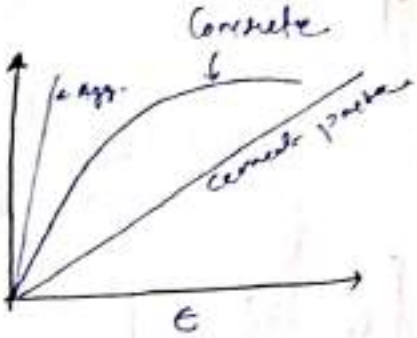
Note! -
Flaky & Elongated makes pore concrete.

Aggregate	Source.
Rounded	river/sea shore, desert & wind blowing flint
Irregular/partly Rounded	Pit sand & gravel, Land or dug flints.
Angular	Crushed rock/stone.
Flakey/Elongated	Laminated Rock

PROPERTIES OF AGGREGATES :-

1. MODULUS OF ELASTICITY (E) :-

E = Aggregate > Concrete > Cement paste.



E → dimensional changes (Creep, shrinkage)
→ but higher internal Stresses.

$$E \propto \text{Internal stress} \propto \frac{1}{\text{Volume changes}}$$

2. BOND STRENGTH :-

Factor Affecting Bond strength.

i) Roughness → Rough Agg. > Smoth agg

ii) Surface Area → (High S.A > Less S.A)
(Angular > Rounded)

iii) Co-efficient of thermal Expansion → Due to difference in co-efficient of thermal expansion of paste and aggregate & because of shrinkage, cracks develope (at interface of paste and aggregate interface which leads to decrease in bond strength.

3. SHAPE & TEXTURE :-

Strength → Angular > Rounded
Workability → Angular < Rounded
} Shape

Strength → Rough > Smoth
Workability → Rough < Smoth
} Texture.

4. Specific Gravity / Bulk Density :-

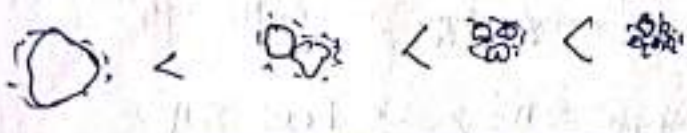
$G \uparrow \Rightarrow$ Weight $\uparrow \Rightarrow$ Porosity $\downarrow \Rightarrow$ Water absorption $\downarrow$

$$G \propto \text{Weight} \propto \frac{1}{\text{Porosity}} \propto \frac{1}{\text{Water Absorption}} \propto \text{Durability}$$

$$G = \frac{W_{agg}}{V_{agg}} \quad \Rightarrow \quad \rho_B = \frac{W_{agg}}{V_{total}}$$

$$\rho_B \propto \frac{1}{\text{void}}$$

5. Moisture Content :-



$$\text{fineness} \propto \text{water adsorption}$$

Bulk	Surface
Dry	Dry
Moist	dry
Moist	Moisture

Water Content = total water (Bulk + surface)

Moisture content = Surface water

* Moisture content is nothing but water adsorp on surface of saturated dry aggregate upon weight of dry saturated dry aggregate.

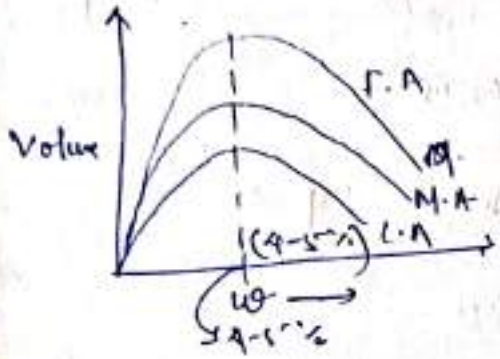
Moisture Content = $\frac{\text{Wt of } H_2O \text{ adsorbed surface of saturated dry agg}}{\text{wt. of saturated surface dry dry aggregate.}}$

Note:- Basic Nature of aggregate → Saturated surface dry.

BULKING OF AGGREGATES :-

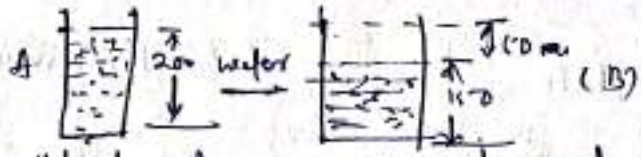
There is an increase in volume of moist aggregate.

Bulking → fine aggregate > Medium aggregate > Coarse Agg



Bulking is due to apparent cohesion between Aggregate particles.

Measurement :-



(Vol ↑) > (Vol ↓)

$$\text{Bulking of sand} = \frac{A-B}{B} \times 100$$

$$= \frac{200-150}{150} \times 100 \text{ units}$$

$$= \frac{50}{150} \times 100 = 33.33\%$$

TESTS ON AGGREGATES :-

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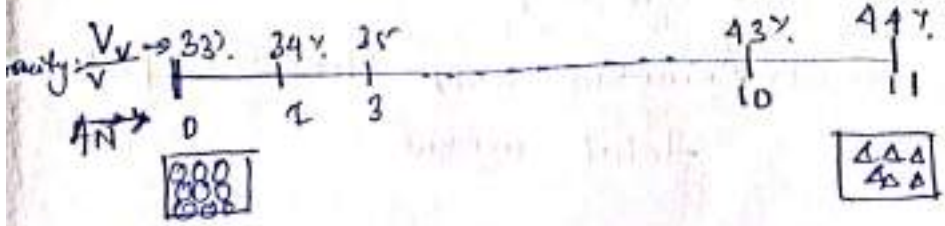
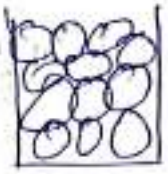
1. SHAPE TEST :-

4. ANGULARITY NUMBER :- Angularity & Void



Example:- Coarse Aggregate $G = 2.65$ is filled in cylinder of volume $0.003 m^3$, whose weight $= 5.217$ gm. Angularity number = ?

Sol:



$$V_T = V_{agg} + V_V$$

$$0.003 = \frac{5.217 \text{ kg}}{2650 \text{ kg/m}^3} + V_V \qquad \frac{MA}{\rho_w G}$$

$$V_V = 0.00102 m^3$$

$$\text{porosity} = \frac{V_V}{V} = \frac{0.00102}{0.003} \times 100 = 34\%$$

Hence, Angularity number $AN = 1$

→ Rounded particles.

B. FLAKINESS & ELONGATION INDEX:- IS: 2386 Part-I

* Flaky particle → Least lateral dimension $< \frac{3}{5}^{th}$ of mean dimension ($0.6 \times$ mean dimension)
* Elongated particle → Least lateral dimension $> \frac{9}{5}^{th}$ of mean dimension. ($1.8 \times$ mean dimension)
* The test is not applicable for particles having size less than 6.3 mm.

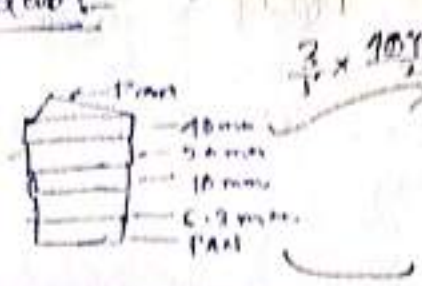
Flakiness Index $\leq 15\%$
Elongation Index $\leq 15\%$

$FI + EI \leq 30\%$

$$F.I. = \frac{\text{weight passing through sieves}}{\text{total weight}} \times 100$$

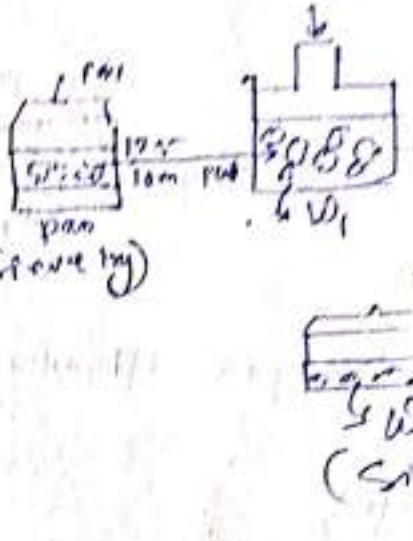
$$EI = \frac{\text{weight Retained through Elongation plate}}{\text{total weight}} \times 100$$

Procedure :-



2. STRENGTH TEST :-

→ Gradual Loading (10 ton)



$$\text{Aggregate Crushing Value (ACV)} = \frac{W_2}{W_1} \times 100$$

Note :-

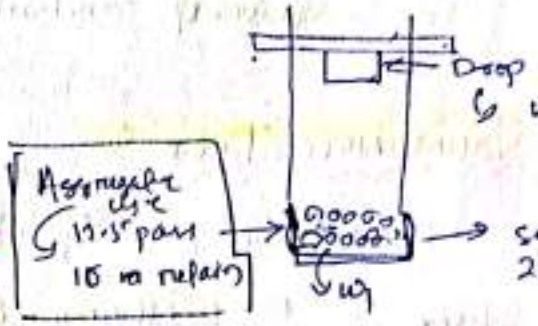
$$ACV \propto \frac{1}{\text{Strength}}$$

- Pavement Construction ACV value ≯ 30%
- General Construction ACV ≯ 45%.

3. TOUGHNESS TEST :-

→ Impact resistance

→ hammer droped from 38cm 15 times.



$$\text{Aggregate Impact Value (AIV)} = \frac{W_2}{W_1} \times 100$$

Note :-

$$AIV \propto \frac{1}{\text{Impact Resistance / Toughness}}$$

- for Pavement construction AIV ≯ 30%
- for General construction AIV ≯ 45%

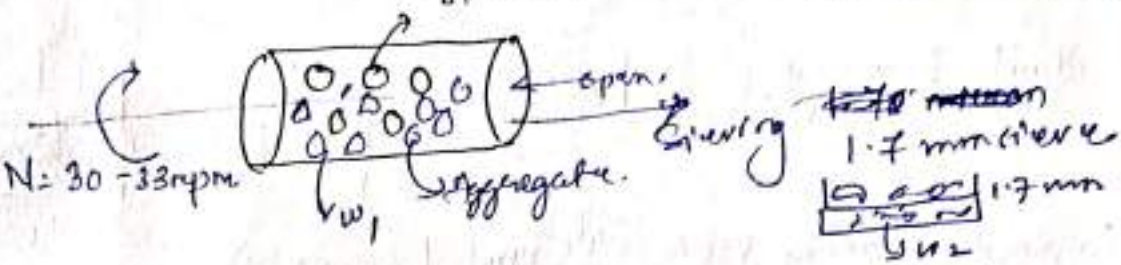
4. HARDNESS TEST / ABRASION TEST :-

a) Deval Abrasion Test.

b) Dorry Abrasion Test.

c) Los Angeles Test.

Procedure (c) :- Steel ball. (8 balls) | dia 48 mm, wt 390 gm



$$\text{Aggregate Abrasion Value (AAV)} = \frac{W_2}{W_1} \times 100$$

Note :-

$$AAV \propto \frac{1}{\text{Abrasion value}}$$

* for pavement Construction, AAV ≯ 30%.
* for general construction, AAV ≯ 50%.

5. SOUNDNESS TEST :-

* It is the ability of an aggregate to resist volume changes. ∴ Weathering Resistance.

$$\text{Volume changes} \propto \frac{1}{\text{Weathering Resistance}}$$

6. SIZE OF AGGREGATE

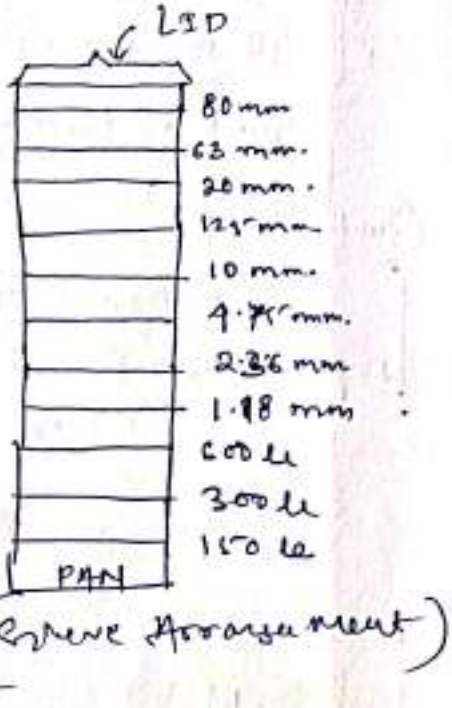
FINENESS MODULUS:-

Help

Sieve - Size according ~~Aggregate~~ Order :-

* 150 μ, 300 μ, 600 μ, 1.180 mm, 236 mm, 4.75 mm, 10 mm,
  ③ ④ ⑤ ⑥ ⑦
  12.5 mm, 20 mm, 63 mm, 80 mm.
  ⑧ ⑨ ⑩ ⑪

Sieve size	Wt. retain	% retain	Cumulative %
80 mm	80 g	8%	8%
40 mm	120 g	12%	20%
20 mm	100 g	10%	30%
12.5 mm			
⋮			
150 μ			
PAN			
	1000 gm.	100%	Σ Cumulative



Sieve Arrangement

Fineness modulus = Sum of cumulative % retained on standard set of sieve

$$F.M = \frac{\Sigma \text{ Cumulative \% Retained}}{100}$$

↳ It indicates average particle size.

1% ≤ F.M. ≤ 11%

Fine ⟵ ⟶ Coarse.

2.9

F.M = 3, then it indicate, Aggregate mean size = sieve size, no ~~20~~.

Fineness Modulus ∝ Size of aggregate

2) Sand (Fine Aggregate) (F.M.)

Fine sand →	2.2 – 2.6
Medium sand →	2.6 – 2.9
Coarse Sand →	2.9 – 3.2

(Fineness Modulus)

*	Coarse Aggregate.	5.5 – 8.
*	All in Aggregate	3.5 – 7.5

* Used in Concrete.

Question 1.

Fine Aggregate	Coarse Aggregate.
F.M = 2.8 (P_1)	F.M = 7 (P_2)

x → Fine Aggregate, (1−x) → Coarse Aggregate

F.M. = 5.4 (P)

$$(F.M)_{Resultant} = \frac{[\{2.8x\} + \{7(1-x)\}]}{x + (1-x)} = 5.4.$$

$$\frac{F.A}{C.A} = Z = \frac{P_2 - P}{P - P_1} \times 100$$

$$\frac{7 - 5.4}{5.4 - 2.8} \times 100 = 0.6$$

* Property of Good Aggregate! –

→ Hard
→ Strength
→ Tough
→ Well graded
→ Durable
→ Inert (non-Reactive)

Zonal Classification of Aggregate :-

IS : 383 - 1970

⇒ fine aggregate in also divided into 4 zones.

~~Use a general size of 4~~

150 < fine aggregate < 4.75

% Passing - Exclusive →	15-34%	35-59%	60-79%	80-100
Zone	I	II	III	IV

→ fine nes

finer :- Zone I < Zone II < Zone III < Zone IV

Size :- Zone IV < Zone III < Zone II < Zone I

Note: Standard Sand :-

IS Standard Sand :- IS 4650

Ennor Sand → Light Grayish white Colour.

Partial size	Gradation %
1 - 2mm	33%
600 μ - 1mm	33%
90 μ - 600 μ	33%

Alkali - Aggregate Reaction :-

→ Aggregate → Inert (non-reactive)
→ Reactive Silica.

→ Alkali + Reactive Aggregate → Compound (Volume ↑)
↳ Alkali silica gel.
↳ Create pressure.

→ Alkali undergo expansive nature.

CH-10 : FLY ASH (POZZALANIC MATERIAL)!-

** INTRODUCTION :- FLY ASH -

→ fly ash is a finely divided byproduct resulting from the combution of Cole in power plants.

→ It contains large amount of silica, alumina, and small amount of unburned carbon, which pollutes environment.

→ It is Gray in Colour and alkaline in nature

→ The particle size ranges between 1 - 100 μ.

→ The Specific Gravity of F.A. Lies between 1.9 to 2.8.

→ The surface area is typically 200 - 500 m^2/kg. although some fly Ash can have a surface area as high as 700 m^2/kg (Around 330 m^2/kg Cement)

→ the mass per unit volume Including air between particals. (Density) can very from 540 - 860 kg/m^3.

→ Silicious in nature.

→ No - self cementing properties.

→ Pozzalanic Material.

** POZZALANA :-

→ Pozzouli, a town in Italy near amount of vesuvious.

→ Volcanic dust around this town when mixed with hydrated lime was found to possess hydraulic or cementitious properties.

→ Pozzolana may be defined as siliceous material which whilst itself of no cementitious properties.

→ Before cement, these pozzolana was mixed with lime.

→ Pozzolana may be natural or artificial, fly ash being common of latter catagories

→ Currently, its use to replace some portion of cement in concrete

→ ADVANTAGES OF REPLACING OF POZZOLANIC MATERIAL :-

→ Economy
→ Workability increase
→ Reducing of bleeding and segregation.
→ Greater Impervioueness
→ Resistance to freezing and Thawing
→ Resistance to Sulphate Attack and water.
→ Reduce Effect of Alkali Aggregate Reaction.
→ Reduce heat of hydration.
→ Reduced Cost.
→ Locally Obtained

→ Type :- CLASSIFICATION OF POZZOLANIC MATERIAL

NATURAL
→ Clay
→ Shale
→ Diatomaceous Earth
→ Volcanic Tuff & PUMICITE
→ Rhenish & Tuscan Barangan Trass

ARTIFICIAL
→ fly Ash
→ Ground blast Furnance Slag
→ Silica fume
→ Surkhi
→ Rice husk Ash.

Note:-

→ The optimum optimum amount of pozzolanic, as replacement of Cement, may normally ranges between 10 – 30 %.

→ Fly Ash ~ Gradation → IS 3812 [CLASSIFICATION OF PCC IS]

Grade – I – (Recommended for manufacturing of OPC)

Grade – II → (Used in mortar as admixture in concrete)

Note

Sl No	Characteristics	Requirement	
		Grade – I	Grade II
1.	Fineness – Specific surface in m^2/kg minimum	320	250
2.	Lime reactivity – Average compressive strength in N/mm^2, minimum	4.0	3.0
3.	Compressive strength for Portland Pozzolana cement	not less than 80 % of the corresponding plain cement mortar cube.	
4.	Drying shrinkage, maximum	0.15	0.10
5.	Soundness – Expansion of specimen percent, maximum	0.80	0.80

→ SPECIFICATION :-

→ Spherical glassy materials ranging from 1 – 150 μ (micron), most of which passes through a 45 μ sieve.

→ More than 40 % of the particles which are under 10 μ contribute to early age strength.

→ Particles of size 10 – 45 μ react slowly and are responsible for gain strength from 28 days to one year

Chemical Compositions :-

→ It is a heterogeneous material containing SiO_2, Al_2O_3 and Fe_2O_3 as major constituent with CaO occasionally being the minor constituent.

→ Exact composition varies according to the percentage coal bed makeup.

→ Also has Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Mercury, Molybdenum, Selenium, Strontium etc. (in the order of hundred ppm).

Note:

~~Component~~

Component (%)	Bituminous	Sub-bituminous	Lignite
SiO_2	20–60	40–60	15–45
Al_2O_3	5–35	20–30	20–25
Fe_2O_3	10–40	4–10	4–15
CaO	1–12	5–30	15–40

Uses :-

→ Admixture for portland cement
→ Soil stabilization
→ Flyash Brick
→ Asphalt Concrete
→ Embankament.
→ Geopolymers
→ As a catalyst
→ Waste Treatment.

EFFECTS :-

1. On amount of water :- Requires little more amount of water as the fineness of flyash : more for fine sands : for coarse sand the addition of flyash produce beneficial result.
2. Strength :- Lower rate in gaining strength as compared to OPC but increases after 2 month provided curing is continued.
3. Shrinkage :- finer flyash & Low carbon content. Reduce shrinkage.
4. Permeability :- Reduce.
5. Resistance to chemical attack :- Increases
6. Heat of hydration :- reduces
7. Setting time :- increase in setting time upto 2hr

In term of usability in Concrete and Cement :-

- → Higher Ultimate strength
- → Increase Durability
- → Improve Workability
- → Reduce Bleeding
- → Increased resistance to sulfate attack
- → Reduced shrinkage.
- → Almost zero emission of greenhouse gases.

• Note!-

* Comparison between normal clay brick to fly ash brick

Sl.no	feature	Normal clay Brick	fly ash Brick
1	Binding	Light	Dense
2.	Colour	Vary	Uniform.
3.	Shape	Irregular	Uniform.
4	Weight	More	Less
5	Compressive strength	30 kg/m²	100 kg/m²
6	Water Absorption	20 – 25%.	6 – 12%.

Note:-

** CLASSIFICATION OF FLY ASH AS PER ASTM :-

→ There are 2 to classes of fly ash as defined by ASTM "ASTM".

1. Class f fly ash
2. Class C fly Ash.

→ This classification is based on the chemical composition of fly Ash. i.e. the sum of Silica, alumina and iron oxide. percentage in the fly Ash. being.

1. minimum of 70% (Class F)
2. Minimum of 50% (Class C)

CH-II : ALUMINIUM :-

Intro :-

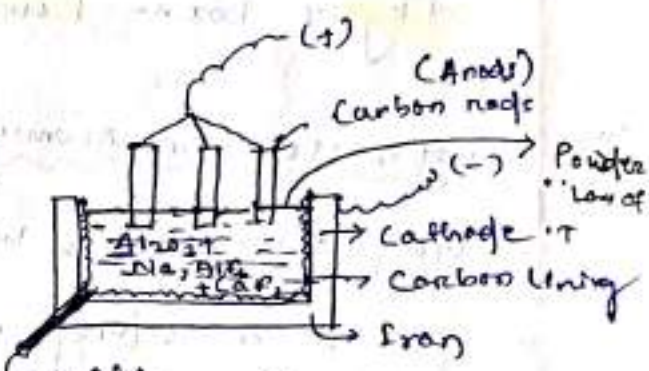
→ There is 8.1 % of Aluminium is present in the earth surface in the one form which is known as **Bauxite**.

→ For the use of aluminium we need to extract the pure Aluminium from the ore. The process is called as manufacturing of aluminium.

→ There are various processes of manufacturing of aluminium. Some discussed bellow.

II. MANUFACTURING OF ALUMINIUM :-

1. HALL - HEROULT PROCESS :-



→ Molten Al_2O_3 (∵ it is bad conductor of electricity)

→ Add Cryolite (Na_3AlF_6) + felspar (CaF_2)

→ It increases electrical conductivity of solution.

→ It decreases melting point of Alumina (2345°K → 1173)

Al^{3+}

O^{2-}

Cathod :- Reduction

$$Al^{3+} + 3e^- \rightarrow Al \text{ (Deposit)}$$

Anode :- Oxidation.

$$C + O^{2-} \rightarrow CO + O^{-2} \rightarrow \boxed{CO_2} \uparrow$$

→ Steel carbon rod are getting diminished of by Charge periodically.

→ 1 kg Aluminium = 0.5 kg Carbon burn

→ [Powdered Coke → Prevent Reduction Loss of heat
Prevent Oxidation.]

III. EXTRACTION OF ALUMINIUM :-

→ The production of 1 kg of aluminium requires around 2 kg of alumina.

→ The production of 2 kg of aluminium required about 4 kg of bauxite.

IV. PROPERTIES OF ALUMINIUM

→ Good conductor of heat and electricity

→ It is a silvery white metal with a bluish tinge and it exhibits bright lustre on a freshly broken surface.

→ It is a non magnetic substance.

→ It is highly resistant to corrosion.

→ It is light in weight, malleable, and ductile.

→ It is very soft.

→ It possess great toughness and tensile strength.

→ Readily dissolves in HCl.

CH-12 FRP & Ceramics

Introduction

4 Types of Materials are:

1. Metal
2. Non-metal
3. Composite
4. & Ceramics

FRP → fibre Reinforced polymer

* General Composition:-

fiber [carbon, Glass, etc] + Resin [Polymer]

(Reinforced by fibers)

* FIBERS:-

Common types of fibers are:-

1. Aramid: (Commertial fiber) / Kevlar:—
   - Extreamely sensitive to environment conditions.
2. Glass: (Most widely used)
   - Subjected to creep under high sustain loading.
   - Subjected to degradation in alkaline environment.
3. Carbon:
   - Premium Cost.
4. Basalt:
   - The future of FRP fiber.

** Used in different forms of fibers:-

1. Short fibers
2. Chopped fibers
3. Long fibers
4. Woven fibers

2) Resins (Polymers)

Two Catagories.

1. Thermoset Resins: (Most common for structural uses)

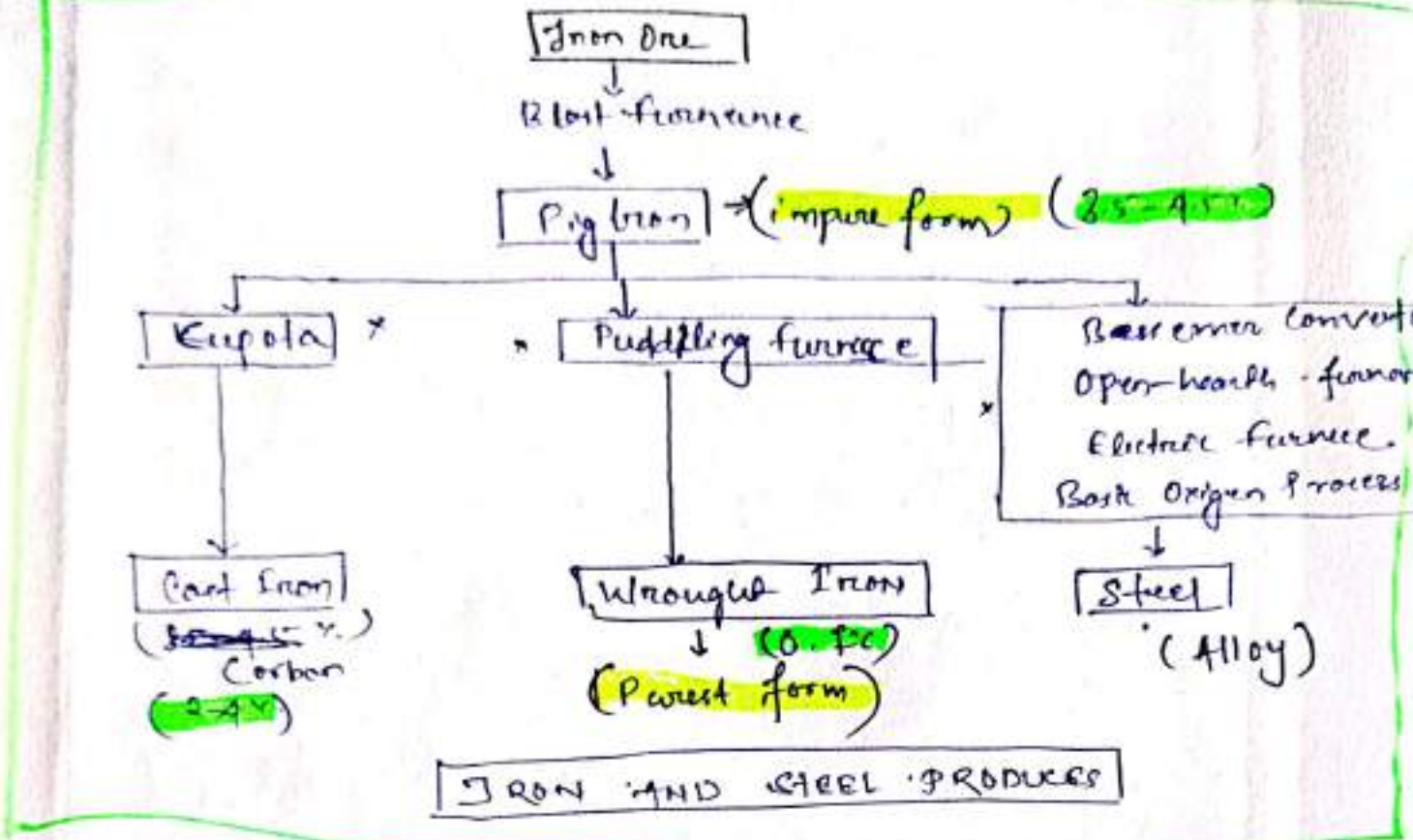
→ Liquid state at room temperature prior to curing.
→ Impregnated into reinforcing fiber prior to heating.
→ Chemical reaction occurs during heating/Curing.
→ Solid after heating/Curing: Can't be reversed/reformed.

2. Thermoplastic Resins:-

→ Solid at room temperature (recycled plastic pellets)
→ Heated to liquid state and pressurized to impregnate reinforcing fibers.
→ Cool Cooled under pressure; Can be reversed/reformed

CH-13. STEEL

* Ferrous metal:-



* CAST IRON V/S CARBON STEEL:-

CAST IRON / Studied steel	CARBON STEEL
→ Cast Iron is hard, relatively brittle alloy of iron and and carbon which can be readily readily cast in a Mould.	→ Carbon steel is a type of steel having high amount of carbon and Low amounts of other element.
→ Contains up to 2-4% carbon	→ Contains up to 1% carbon.
→ More brittle due to the presence of high amount of carbon.	→ Stronger than cast Iron
→ Less ductile	→ More ductile.
→ Has relatively a low melting points.	→ Has relatively a high melting point.
→ Composed of iron along with Carbon, silicon, manganese of Sulphur and phosphate as well.	→ Contains mainly iron and carbon. Other element can be present in trace amounts.

Intro:-

Steel

→ Steel is an alloy of iron and carbon.

→ It is one of the most commonly materials in the world.

→ It is a major component in building, infrastructure, tools, ships, automobile, machine, appliances, and use. weapons.

→ Type of steels:-

(i) Carbon steel
(ii) Alloy steel
(iii) Stainless steel.
(iv) Tool steel

→ Mild steel has carbon content = 0.1 – 0.2%.
Cast iron " " = 2 – 4%.

Note:-

Non Alloy and Low carbon steel with C from 0.16 to 0.29%. which is used in 85% of all steels application in the world.

Eg – Mild steel.

Steels = Fe + Carbon (C ≤ 2.14%)

NON ALLOY STEELS
(Plain Carbon) Steel
(Fe + C)

a) Low Carbon (C < 0.3%)
(Mild steel) (0.16 – 0.29)
b) Medium Carbon (0.3 – 0.6%)
c) High carbon (0.6 – 1%)
d) Ultra High Carbon (1 – 1.7%)

ALLOY STEEL
(Fe + C + Alloying element)

a) Low Alloy (EAE < 5%) — several types (Si, Mn, Cr+Mo etc)
b) Medium Alloy (5% ≤ EAE < 10%) → Cr – Mo, Cr – Mo – V, Ni
c) High Alloy (EAE ≥ 10%) → Ni (Maraging), Cr – Ni (Stainless steel), Mn.

2- ADVANTAGES OF STRUCTURAL STEEL :—

1. In Design :—

→ large span
→ with column of sum section.
→ Great building heights.. and high loadbearing capacity.
→ combined with Low dead & weight of the structure.
→ Structural systems in which openings can be easily provided.
→ To simplify installation of services.

2. In Construction :—

→ Prefabrication and erection of components.
→ Shorter construction time.
→ Close dimensional tolerances
→ Ease in fixing and cladding
→ Erection independent of weather conditions.
→ Modest demand on space on the site.
→ Dry construction.

3. In Use :—

→ Greatest flexibility
→ Limited no. of internal supports.
→ Adaptability of frame work to change use.
→ Increasing effective life of building
→ Ease in dismantling or demolition.

* Effect of Alloy Element :- (+ increase, − decrease)

1. Carbon (C) → + Streangth, + Hardenability, − Toughness.
2. Chromium (Cr) → + Strength, + Heardendability, + Corrosion Reesistance, − Toughness.
3. Molybdenum (Mo) → + Strength, + Heardenability, + toughness, + Hot hardness.
4. Vanadium (V) → + Heardenability, + Toughness, + Hot hardness + wear and tear.
5. Tungsten (W) → + Strength, + Hardenability, + Hot hardness. − Toughness.
6. Cobalt (Co) → + Hot Hardness, + Wear, − Toughness.
7. Manganese (Mn) → + Strength, + Heardnability, + Toughness.
8. Nickel (Ni) → + Hardnability, + Toughness, + Corrosion Resistance.

CH-19: PAINTS AND VARNISHES

A. PAINT :-

A coloured substance which is spread over a surface and dries to leave a thin decorative or protective coating

* Objective :-

- → Protection of base material.
- → Decorative purpose.
- → Increase durability
- → Simple maintanance
- → Water protecting / proofing.

CHARACTERISTIC OF FORAL PAINT :-

- → Ease to application
- → Reasonable drying period.
- → forming a thin film without cracking.
- → Forming a hard and durable coating.
- → Its performance should not be affected by weather.
- → Not harmful for users.
- → Attractive apearience.
- → Easily spread on surface.
- → Should remain free from cracks.

TYPE OF PAINTS :-

1. OIL PAINT :-

→ Oil paints are applied in three coats :- primer, under coat and finish coat.

→ Oil paint can achive mat and glossy finishes, while being durable and affordable.

→ They are characterized by their ease of application, and painted surface are easy to maintain clean.

→ Oil paints are commonly used on walls, doors, window and metal structure.

2. ALUMINIUM PAINT :-

→ It is resistant to corrosion, electricity and weather exposure.

→ It is commonly used for metal and wood, and some specific are gas tank, oil tanks, water pipe and radiators.

3. ANTI CORROSIVE PAINT :-

→ It mainly resist corrosion hance used on metal surface.

4. BITUMEN PAINT :-

→ It is suited to many different applications because of its weatherproofing, corrosion resistance, and adhesive properties.

→ It is primarily used as a protective coating for building structure, and items constructed from iron, steel, concrete, masonry and wood.

5. CELLULOSE PAINT :-

→ This type of paint is characterized by its quick drying, smooth finish, and headness, while offering resistance to water, smoke, and acids.

6. ENAMAL PAINT :-

→ This type of paint is prepared by adding lead and zinc to varnish.

→ Enamal paint form hard and glossy coating, which are easily clean.

→ They are characterized by being waterproof and chemically resistant, offering good coverage and colour retainlion.

→ Used in interiors and exterior walls, window, door, stairs etc

7. PLASTIC PAINTS :-

→ This paint uses water as thinner, and it is available in a wide range of colour. It dries very quickly and offers high coverage.

→ This is used in slabs, ceiling, walls, ceilings of auditorium and club etc.

8. CEMENT PAINT :-

→ Cement paint is available in powder form, which is mixed with water to achive pain consistency.

→ The base material is white or colored cement, and it may also contain pigments, accelerators and other additives.

→ Cement paint is durable and water proof, and it is commonly used in rough internal and external surface.

9. ASBESTOS PAINT :-

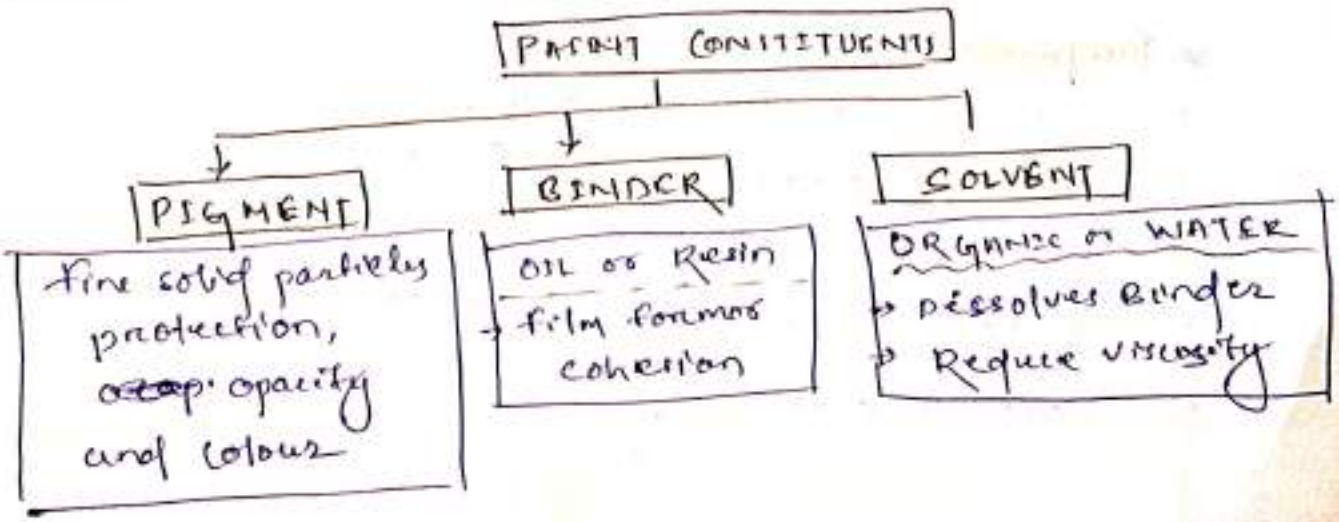
→ The fibrous asbestos is present in these paints.
→ This is mainly applied to avoid the leakage of water roofs
→ It can also be used for painting spouts, gutters.
→ Also applied for dump proofing of surfaces in the basement walls.
→ Most fire Resistant paint.

Note: Asbestos forms by → (Cement + Sand) under pressure.

10. SYNTHETIC RUBBER PAINT :-

→ This paint is prepared from resins.
→ It dries quickly and it little affected by weather and sunlight.
→ It resist chemical attack well.
→ This paint may be applied even on fresh concrete.
→ Its cost is moderate and it can be applied ~~easily~~ easily.

CONSTITUENTS OF PAINTS :-



Constituent of paint:-

1. BASE:-

→ It is the principal constituent of paint.
→ It also posses the binding properties.
→ It forms an opaque coating.
→ Commonly used bases are white lead, Red lead, Zink oxide, Iron oxide, Titanium white, Aluminium powder and Lithophone.
→ If Lead paint is suitable for painting iron and steel work, as it sticks to them well, however it is affected by atmosphere action and hance should not be used as final coat coat.
→ White Zink forms good base but it costly.

2. FILLER/EXTENDER:-

→ Do not provide colour.
→ Poore Optical properties (reflection, opacity etc).
→ It improve Adhesive.
→ If extender pigment added are of needle shaped or flaked shape, the setting may be very little.

Purpose:-

→ ~~Thekan~~ Thicken the film.
→ Increase volume, Paint film thickness.
→ reduce cost of paint.
→ Impact: toughness, abrasion resistance & texture.
→ Control consistency.

3. PIGMENTS:-

→ Pigments give required colour for paints.
→ They are fine particles and have a reinforcing effect on thin film of the paint.
→ The common pigments for different colours are:-

- Black → Lamp black, suit and charcoal black.
- Red → Venedion red, red lead and Indian red.
- Brown → Burnt timber, raw and burned sienna.
- Green → Chrome green, Copper sulphate.
- Blue → Prussian blue and ultra marine.
- Yellow → Ochre and chrome yellow.

4. VEHICLE/ CARRIER:—

→ The vechicle are the liquid substance which holds the ingredients of a paint in liquid suspension and allow them to be applied on the surface to be painted.
→ Commonly used: Linseed Oil, Tung Oil, and Nut oil are used as vehicles in paint.
→ Linseed oil is very commonly used vehicles, Boiling make the oil thicker and darker.
→ Linseed oil react with oxigen and harden by forming a thin film.

5. THINNER/ SOLVENT:—

→ It is known as solvent also.
→ It makes paint thinner and hence increase the coverage.
→ It helps in spreading paint uniformly over the surface.
→ Terpentine, Benzene and Naptha are commonly used thinner.
→ After paint applied, thinner evaporates and paint dries.

6. Drier:-

→ There are the compound of metal like Litharge, Manganese dioxide, Lead Acetate, cobalt cotoate.

→ The function of drier to is to absorb oxigen from air and supply it to the vanish vehicle for hearderning.

→ The drier should not be added until the paint is about to be used.

→ The excess drier is harmful because it destroy elestiverty and cause flaking.

→ It is added of about 8% of the total volume.

Note:-

(1) Eg.

Base Vehicle Pigment	+	Thinner filler Drier	=
[Added at the time of Manufacturing]		[added at the time of painting]	

Note-2

Red Lead → Matallic surface. (Due to corrosion)
White Lead → Timber surface. (Not - Corrosion)
Iron Oxide → Used to as primer on matal surface.
Titanium White → Used before enamal paint.

DEFECTS IN PAINTS :-

1. BLUSTERING :-
formation of bubbles on painted surface. because of water vapour is trapped in inner surface of the paint.

2. FADING :-
Gradual loss of colour due to sun light, water.

3. EFFLORESCENCE :-
Due to presence of alkalis in weather white fluffy patches appear on paint surface.

4. FLAKING :-
Detachment of some portion of paint film from surface due to poor adhesion.

5. GRINNING :-
Thickness of final coat becomes so thin so that background is clearly visible.

6. CHALKING :-
White chalking powder on surface due to insufficient oil.

7. RUNNING :-
→ flowing of paint on wall surface due to excessive addition of thinner.
→ small uncovered area due to running of paint on smooth surface.

8. SAGGING :- When the wet paint flows downward on vertical surface due to gravity, creating uneven thickness and potentially stripping or forming wrinkling.

9. BLOOMING :-

formation of dull patches due to poor quality of paint and poor ventilation.

10. WRINKLING :-

When thick layer of paint is applied wrinkles formation takes places.

11. SAPONIFECATION :-

formation of sharp patches on paint surface due to presence of alkalies in wet environment. atmosphere.

12. ALLIGATORING :-

alligator cracks on paint due to excessive shrinkage & dryness.

13. MILDUR :- Appearence of black, gray or brown spots primarily in damp, poorly ventilated areas like bathroom and under eaves.

B. VARNISH :-

Intro :-

Resin + oil / Alcohol → Varnish

Varnish is a solution of some resinous substance in alcohol or turpentine. The process of covering the surface with varnish is known as Var Varnishing.

Varnishing is done only on wooden surfaces.

Constituents of Varnish :-

1. Resin :-

2. Solvent :-

3. ~~Drier :-~~

3. Drier :-

FUNCTION OF VARNISH :-

Varnish performs the following function

(i) It brings about brilliance to the painted surface.

(ii) It protects the surface against adverse effect of the atmosphere.

(iii) It increase the durability of paint film.

(iv) It beautifies the surface without hiding the beautiful grains of wood.

TYPES OF VARNISH :-

1. OIL VARNISH :-

→ This type of varnish is manufactured by dissolving hard resins such as amber and copal in linseed oil.

→ Turpentine may be used in small quantity to thin the varnish, and also to render it workable.

→ Oil varnishes form a hard and durable film, but they dry slowly.

2. SPIRIT VARNISH :-

→ This type of varnish is prepared by dissolving resins such as lac or shellac in methylated spirit spirits.

→ The varnish dries very quickly and get easily effected by weather action.

→ This varnish is mostly used for wood furniture.

3. TURPENTINE VARNISH:-

→ In this type of varnish, Gum Dammar, Mastic, and Rosin like resins are used dissolved in turpentine oil.

→ These varnishes are light in colour.

→ They dry quickly.

4. WATER VARNISH:-

→ This varnish is prepared by dissolving shellac in half water.

→ Shellac is dose not dissolve readily in water and such as to accelerate the process of dissolving shellac in water either ammonia or potash, or soda or borax is added.

→ This varnish is used for painting pictures, posters and maps.

6. ASPHALT VARNISH:-

→ This varnish is obtained by dissolving melted asphalt in linseed oil.

→ The varnish may be thinned by adding suitable amount of either turpentine or petroleum spirit.

→ This varnish is used for varnishing fabricated iron and steel product.

7. FLAT VARNISH:-

→ This is an ordinary varnish to which material such as wax, finely divided silica and metallic soaps are added. to reduce the gloss of the varnished surface.

→ The varnish presents a dull appearance.

8. SPAR VARNISH :-

→ that varnish derives its name from its use. It is mostly used on spars and other exposed part of the ships.

→ It is very good in weather resistance. It should not be used indoor.

→ Spar - a thick, strong pole such as is used for a mast or yard on a ship.

DISTEMPER :-

It is may be defined as water paint consisting of.

→ A whiting (powdered chalk)

→ Colouring pigment (if desired)

→ A Binder such as Glue or casein mixed in water.

Note :-

Base Chalk
Thinner = Water

→ It is cheaper

→ It is used for interior surface not for exposed surface.

→ It is less durable

Type of Distemper :-

1. Soft Distemper :- It is not abrasion resistance and may include binders such as chalk, ground pigments, and animal glue.

2. Hard Distemper :- It is stronger and wear-resistant and can include casein or linseed or oil as binders.

Properties of Distempers :-

1. Distempers generally shrink on drying. Hence, if the surface receiving distemper is weak, it may lead to cracking and flaking of the distempers.
2. Distempers are available in powder form and also in paste form.