BUILDING MATERIAL AND CONSTRUCTION

Constituent of Portland Cement (Raw material) :-

Trick :- L – SAI – MAIST

avg. % order

Lime (63%) > Silica (20%) > Alumina (6%) > Iron oxide (3%) > magnesia (2%) > Alkalies (1%) > SO_3 (Sulpher tri acid) (1.5%)

Approx 1% both.

oxide	composition (%)	Avg (%)	function	if Excess quantity then ?
lime (CaO)	60-65	63	Controll → Strength, Soundness Deficiency → Strength ↓, Settingtime ↓	unsoundness
Silica (SiO_2)	17-25	20%	Strength	Cause Slow Setting
Alumina (Al_2O_3)	3-8	6%	quick setting	lowers Strength
Iron oxide (Fe_2O_3)	0.5-6	3%	color + fusion of different ingradient ⟷ (same) • acts as flux	
magnesia (MgO)	0.5-4	2%	color + Hardness	Cracks in mortar, makes unsound cement.
Alkalies ($Na_2O + K_2O$)	0.5-1	1%	Residues	efflorescence & cracks.
Sulphertrioxide (SO_3)	1-2	1.5%	—	makes cement unsound.

conclusion

(I) Strength Responsibility < lime, Silica

(II) Quick setting → Alumina

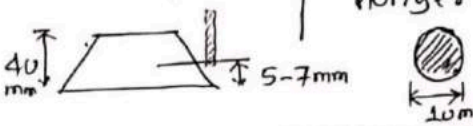
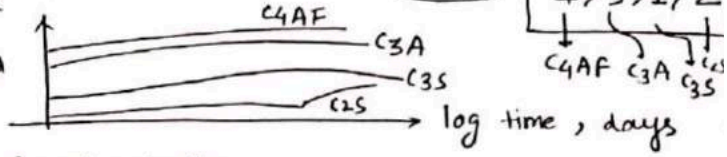
(III) hardness → magnesia, Iron oxide

(IV) Soundness → Sulpher, lime, magnesia

Initial Settingtime < Gypsum, Silica

19/2/2020

Ayaz 19/2/2020

ement Test name	Purpose	Imp. points
Fineness Test	measure mean size of grains	→ Sieve method → use 90 μ Sieve → find % residue → Air permability method → Nurse & Blane's method → Sedimentation method → Wanger turbidity method * In Air permability method fineness measured in $\frac{cm^2}{kg}$ (Specific surface area (SSA)) % residue by weight / SSA cm^2/gm: OPC 10 / 2250; PPC 5 / 3000; RHC 5 / 3250
consistent Test (P %)	to find quantity of water to form a paste of normal consistency	Vicat apparatus | 10 mm dia. Plunger | 50 mm length 
Initial setting time (0.85 P %)	to get IST	vicat apparatus | Square needle (1×1) mm  | note:- OPC IST min = 30 min
final setting time (0.85P) %	to get FST	vicat apparatus | 5mm dia annular ring ○ | OPC FST max = 10hr
Soundness Test (0.78 P) %	to check soundness of cement means volume change after setting of cement	→ Le chatelier Test → for lime only free → ✱ 10mm → Autoclave Test → for lime & magnesia free → ✱ 0.8 % * no Test for 'sulpher'
compressive strength Test (P/4 + 3) %	to check comp. strength (OPC) MPa	• Cube of 50 cm^2 surface area & side = $\sqrt{50}$ cm • take cement : sand ⇒ 1 : 3 • min 3 cube • 27 ± 2°C • cube cast in 2 layers in leakproof method grade: 33 / 43 / 53 — 3 day ± 1hr: 16 / 23 / 27 — 7 day ± 2hr: 23 / 33 / 37 — 28 ± 4hr: 33 / 43 / 53
Tensile strength Test 'or' Briquette Test (P/5 + 2.5) %	to get tensile strength	min 6 Briquette (OPC) ✱✱ 3 days ≥ 2 MPa 7 days – ≥ 2.5 MPa
Heat of hydration Test → 〃		Calorimetur method ① Rate of Hydration :- Trick (4-3=1) ✱✱ Hard 4 > 3 > 1 > 2 ↓ C_4AF C_3A C_3S C_2S  ② Ratio of heat evaluation :- (if equal amount of all taken) Trick 3+1 = 4 3 > 1 > 4 > 2 ↓ C_3A C_3S C_4AF C_2S Jule/gram: 865 500 420 260
specific gravity Test → 〃		Lechatilier flask | OPC Specific gravity around = 3.15

Day: 19/12/2020

Bouge's compound :-

Name	Symbol	Nick name	Avg %	Composition (%)	Properties
Tri calcium Silicate ($3CaO.SiO_2$)	C_3S	Aelite	40	30 – 50	• Best cementing material • early strength ∴ use → road works, cold, Prefabrication work • resistance to freezing & thawing (FT)
Di calcium Silicate $2CaO.SiO_2$	C_2S	Belite	32	25 – 40	• late strength (ultimate strength) < dam, bridge • resistance to chemical attack (CA)
Tri-calcium aluminate $3CaO.Al_2O_3$	C_3A	Celite	10	8 – 12	• flash set { due to Alumina → quick setting) • most responsible for initial setting time (IST) • resistance to sulphate attack (SA)
Tetra Calcium Alumino ferrite	C_4AF	felite	8	6 – 10	• Poorest cementing material • responsible for flash set but generate less heat

Difference b/w Flash set & False set

Flash set (Quick set)	false set
→ rapid development of Permanent rigidity along with (High) heat of evolution	→ rapid development of rigidity { Premature Stiffening or hardening } in fresh mix cement paste, mortar, concrete with (no appreciable) evalution of heat.
Reasons :- (i) C_3A ↑ (more) (ii) Zypsum ↓↓ (less) (iii) Presence of Alkalies (normally sulphates)	Reasons :- (i) Intergrinding too hot clinker, zypsum dehydrate and forms zypsum hemihydrate ($CaSO_4.\frac{1}{2}H_2O$) (ii) Presence of alkalis

Type of cement	Imp. points
(i) RHC (rapid hardening cement)	• gives early strength • C_3S↑ (upto 50%) C_2S↓ → used where early development of strength required ex. repair of roads, bridges and in structures where load is applied in short period of time.
(ii) Extra Rapid hardening cement	• RHC + 2% $CaCl_2$ (accelerator) → max. 20 min for mix, transport, placement, compaction, finishing → used for special purpose (repair work in cold weather) → not used in Prestress concrete
(iii) Sulphate resisting cement	• C_3A↓↓ (<5%) [$C_3S \geq C_2S = 40\%$ approx) → used in structure in sea water / marshy land / sewage / canal lining / culvert / syphon / marine str. → temp ≯ 40°C
(iv) Super sulphated cement	• C_3A < 3.5% • T ≯ 40°C • should not used with any admixture
(v) High Alumina cement IST = 3.5 to 4 hr. FST = 5 to 5.5 hr	• made by fusion of lime + Boxite • used for refractory concrete • In Industries for precasting works • extremly resistance to fire, chemical, seawater, acid attack, sulphate attack.
(vi) Low heat cement IST = 1 hr	• low heat evolution • used in mass concreting. (C_2S↑↑) {C_3A↓↓, C_3S↓↓}
(vii) Quick setting cement IST = 5 min FST = 30 min	• Zypsum free cement • sets quickly but not harden quicky. • used in under water concreting / running water construction
(viii) PPC	• made by pozolonic material like Risehusk, surkhi, flyash, shale etc • Use in mass concreting & Place of high temperature.
(ix) Air entraining cement	• made by airentraining agent like oil / fat / woodrasin / vinsolrasin etc. • greater resistance to freezing & thowing action • Improve work ability • reduce strength • higher IST, FST than OPC
(x) Blast furnace slag cement	• Best for marine works • for pipe carrying water containing chemicals, • Sewage pipe • work exposed to sulphate environment in the soil or in ground water.
(xi) white & colored Portland cement	• for flooring works • Plastering of walls • ornamental works

Uy 2
20/2/20

Composition of Good Brick earth :-

Trick – सलीम

SALIM
- S → Silica (maximum (50-60%))
- A → Alumina
- L → lime
- I → Ironoxide
- M → magnesia

Ingradient	function	Effect in excess
Silica (50-60%)	• Responsible for strength, shape, hardness, durability • prevent cracking, shrinkage, warping of green brick	• Bricks become brittle & weak { ∵ excess of silica destroy the cohesion b/w particles }
Alumina (20-30%)	• Impart plastic qualities so that Brick can be moulded noti:- clay having high Alumina are found to be refractory	• It causes cracks on drying and becomes too hard when burnt.
lime (≯5%)	• acts as flux • causes silica to fuse during burning and bind brick particles together • prevent shrinkage on drying	• In the form of lumps cause brick to disintegrate & brick shape is lost. { Brick to melt → disintegrate → shape lost
Ironoxide (5-6%)	• like lime it acts as a flux helping silica to fuse during burning and bind Brick particles together thus gives strength, hardness • impart red color to brick { color Intensity ∝ Ironoxide quantity • Improve durability & Impermeability	• dark Blue color"
magnesia (<1%)	• gives yellow tint to brick & decrease shrinkage	decay of Bricks

Uy

Harmful Ingradient in brick earth :-

① lime	• if lime is present in lumps, It absorbs moisture, swells & cause disintegration of bricks.
② Iron pyrite	• if iron pyrite present ⟶ It oxidise the brick ↓ Crystallise the brick ↓ Spitting of brick • pyrites ⟶ discolorise the brick
③ Pebbles, gravels, grit	• leads to not proper mixing ⟶ ∴ weak & Porous brick (not uniform mixing)
④ Alkalies	• Excess of Alkalies causes brick to melt & lack their shape • These causes Efflorescene { when brick absorb moisture, on drying moisture evaporates leaving behind white or grey deposits which spoil appearance
⑤ organic matter and vegetation	• organic matter burns ⟶ leaves pores ⟶ make brick Porous ↓ % water absorption ↑↑ ↓ ∴ % strength ↓↓
⑥ Sulphel	if Insufficient time is given to burning for oxidation of carbon & sulphes then sulphes will cause formation of spongy, swollen structure in brick { Bloating Phenomenon }** and brick will be discolored by white blotches.

Alyaa
20/2/20

Defects in Bricks :-

Defect	Explanation / reason
(i) Over-burning of brick	• if Brick overburnt ⟶ Soft molten mass produced ⟶ Brick loose shape ⟶ ∴ such Brick not use for construction
(ii) Under-burning of Brick	• if Brick not burnt properly ⟶ pores not closed due to less heat ∴ higher degree of water absorbtion ↑ ⟶ strength ↓↓ ∴ such brick not recommended for construction.
(iii) Bloating	• This defect is observed as spongy swollen mass over the surface of burnt brick • This defect is caused due to Presence of Excess Carbonaceous matter & sulphur in clay Brick
(iv) Black core	• when Brick clay contains Bituminous matter or carbon and if they are not completely removed by oxidation, The brick result in black core mainly because of Improper burning.
(v) Efflorescence	• cause because of Alkalies present in Brick. when brick comes in contact with moisture, water is absorbed, after drying ⟶ white powder patches on brick surface (ugly appearance)
(vi) Checks or cracks	This is because of lumps of lime or excess of water.
(vii) spots	if Sulphide is present in brick clay It causes dark surface spot on brick such brick not only harmful but also unsuitable for exposed masonary work.
(viii) Blisters	Broken Blisters generally caused on the surface of sewer pipes and draintiles due to air imprisoned during moulding.
(ix) Laminations	It is by the entrapped air in voids of clay • Laminations Produce lamina on the brick faces which weather out on exposure. Such bricks are weak in structure.
(x) Chuffs	Deformation of the shape of brick cause by the rainwater falling on hot bricks

Qualities of good bricks :-

① **Size and shape :-**

- Brick should have uniform size and plane, rectangular surface with parallel sides and sharp straight edges.

② **Color :-** • uniform deep red / cherry color as indicative of uniformity in chemical composition and toughness in the burning of brick.

③ **Texture and compactness :-**

- Surface should not be too smooth to cause slipping of mortar.
- The brick should have precompact and uniform texture.
- A fractured surface should not show fissures, thalis grit or lumps of line.

④ **Hardness :-** • Brick should be so hard that when scratched by finger nail no impression is made.

⑤ **Soundness :-** when 2 bricks are struck together, a metallic sound should be produced.

⑥ **water absorption**

$W_{24} \leq 20\%$ of its dry weight when kept immersed in water for 24 hours.

⑦ **Crushing strength** $\geq 10 MPa$

{ note :- common building brick should have min. crushing strength = 3.5 MPa }

⑧ Brick earth should be free from stones, grit, organic matter etc.

⑨ Brick should not break into pieces when dropped flat on hard ground from a height of 1 metre.

⑩ when soaked in water for about 24 hours, should not show deposits of white salts when allowed to dry in shade.

⑪ Brick should have low thermal conductivity and should be sound proof.

note :- As per IS: 1077-1992 standard size of common building brick —

{ 19 x 9 x 9
  19 x 9 x 4 } (cm)

Test of Bricks :-

① Water Absorption test { water absorption depend on porosity; all brick absorb water by capillary action.

Absorption

- Absorption
  - 24 hr Immersion cold water Test
    - (i) Dry bricks kept in oven (110 ± 5°C) till it attains constant mass (W_1) then cool then weight
    - (ii) Brick immerse in water at (27 ± 2°C) for 24 hours.
    - (iii) Bricks taken out of water and wiped with a damp cloth & weight (W_2) recorded.

    water absorption in W_{24} % $= \frac{W_2 - W_1}{W_1} \times 100$

    note:-

1st class brick	W_{24} ≯ 20 %
2nd "	≯ 22 %
3rd "	≯ 23 %
common Building Brick	≯ 25 %

    * In some source 3rd class Brick 25% is given
    → ans. will be based on option available in exam.

  - 5 hours Boiling water Test
    - (i) same (W_1) noted
    - (ii) Specimen immersed in water → heated to boiling in 1 hr and boiling continuously done for 5 hours. followed by cooling down to 27 ± 2°C by natural loss of heating within 16-18 hours.
    - (iii) Brick taken out of water and wiped with a damp cloth & weight (W_3) recorded.

    Water absorption

    W_5 % $= \frac{W_3 - W_1}{W_1} \times 100$

    note:-

    Saturation coefficient $= \frac{\text{24 hour water absorption } (W_{24})}{\text{5 hour " } (W_5)}$

    aim → to Predict durability of brick.

- Absorption
- Initial Rate of absorption (IRA) or Suction
  - → rate of how much water a brick draws in during the first minute after contact with water
  - → suction has direct bearing on bond between brick and mortar.
  - → when a brick has high suction a strong, watertight joint may not be achieved. High suction brick should be wetted for three to 24 hr Prior to laying to reduce the suction and allow the bricks surface to dry
  - → very low suction brick should be covered and kept dry on Jobsite

note:-

(i) Generally bricks are soaked in water before use in masonary work so that they don't absorb water from cement.

(ii) Average water absorption shall not be more than 20% by weight upto 12.5 class brick and 15% by weight for higher class.

(iii) for water absorption less than 5%, danger of frost action is negligible.

② Compressive strength Test :

- compressive stresses of brick provides a basis of comparison of good quality of brick, but It is of little value in determining the strength of wall ∵ wall strength mainly depends on strength of mortar.
- Take 5 brick sample ⟶ immerse in water at room temperature for 24 hours.
- frog and all voids in bed faces of brick are filled flush with cement mortar (1:3)
- It is then stored under the damp Jute bags for 24 hours followed by immersion in clean water for 3 days
- the brick specimen is then placed with flat faces horizontal and mortar face facing upward between plates of compression Testing machine.
- load is then applied axially at a uniform rate of 14 MPa per minute till failure occures and maximum load at failure is noted.
- $\text{compressive strength} = \frac{\text{max. load at failure}}{\text{loaded area of brick}}$
- Average of 5 results noted.

Types of brick	compressive strength MPa
1st class	≯ 10.5
2nd	≯ 7
3rd	≯ 5
common building Brick	≯ 3.5

③ Efflorescence Test :-

aim → to check Presence of soluble salts or alkalis

- Place brick specimen in glass dish containing water to a depth of 25 mm in well ventilated room, after all the water is absorbed or evaporated again water is added for a depth of 25 mm. after second evaporation the bricks are observed for white/grey deposits.

category	Deposits of efflorescence
Nil	Imperceptible (no Patches)
Slight	≯ 10 % of exposed area of brick
moderate	≯ 50 % (10 - 50 %)
Heavy	> 50 % but deposits don't powder or flake away the brick surface
Serious	> 50 %, deposits are heavy with powdering or flaking the surface

note :-

for upto class 12.5 ⟶ should not be more than moderate (10 - 50 %)

for higher class ⟶ shall not more than slight (≯ 10 %)

④ warpage Test :-

warpage ⟶ Bend or twist out of shape, especially from a straight or flat form.

Sampling :- 10 bricks are taken randomly from a lot as a sample for warping Test.

Apparatus :- warpage of brick is measured with the help of flat steel or glass surface and measuring ruler graduated in 0.5 mm divisions or wedge of steel 60×15×15 mm.

Procedure

1- remove any adhering to the surface of bricke

2- concave warpage :- The flat surface of the brick is placed along the surface to be measured selecting the location that gives the greatest deviation from straightness. The greatest distance of brick surface from the edge of straightness is measured by a steel ruler or wedge.

3 convex warpage :- The brick is place on the plane surface with the convex surface in contact with the flat surface and the distance of 4 corners of brick are measured from the flat surface. the largest distance is reported as warpage.

Result :- The highes of the distance measured in concave and convex warpage tests is reported as warpage.

---

⑤ Hardness Test :-

No Impression should be left on the brick surface when scratched with a finger nail.

---

⑥ Soundness Test :- 2 bricks are struck with each other. They should not break and should produce a clear ringing sound.

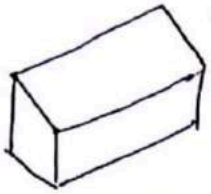
---

⑦ Structure Test :- A brick is broken and its structure is examined, It must be homogenous, compact and free from any defect such as holes, lumps etc.

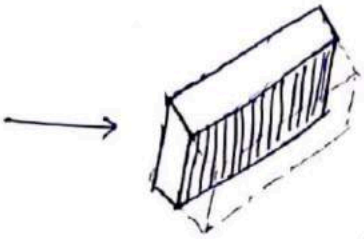
Special type of Brick

(Used in Brick masonary)

(I)



full brick

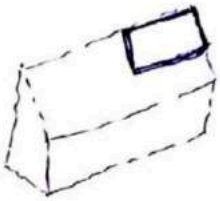


Queen closer half

↓

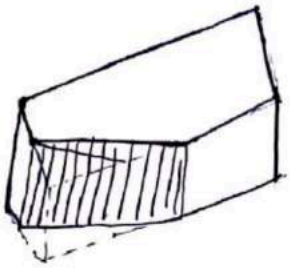
longitudinally cut in 2 parts

again cut



Queen closer (Quarter)

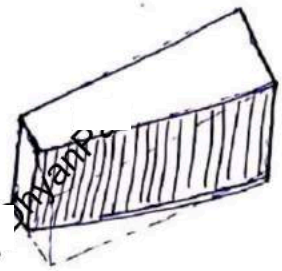
(II)



(King closer)

Trick Mid – Mid cut

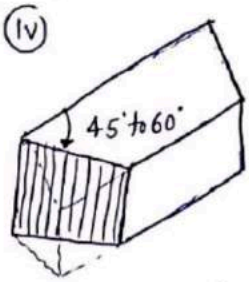
(III)



Bevelled closer

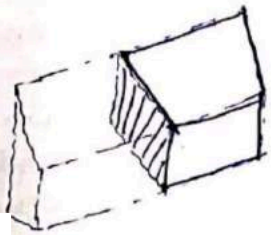
(Trick mid – corner cut)

(IV)



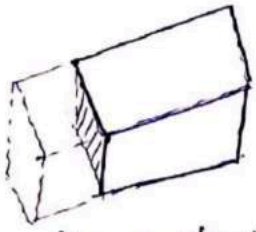
(mitred closer)

(V)



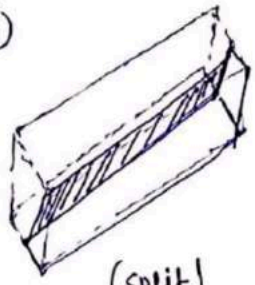
(half or bat or halfbat)

(VI)



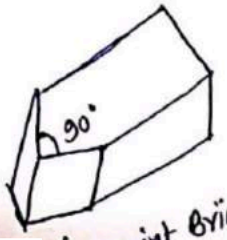
three Quarter closer or three Quarter Bat or 3/4th Brick

(VII)



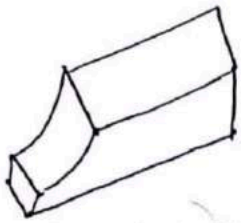
(Split)

(VIII)



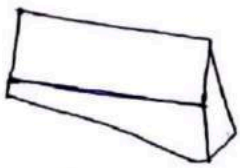
(Squint Brick)

(IX)



(Cornice brick)

(X)

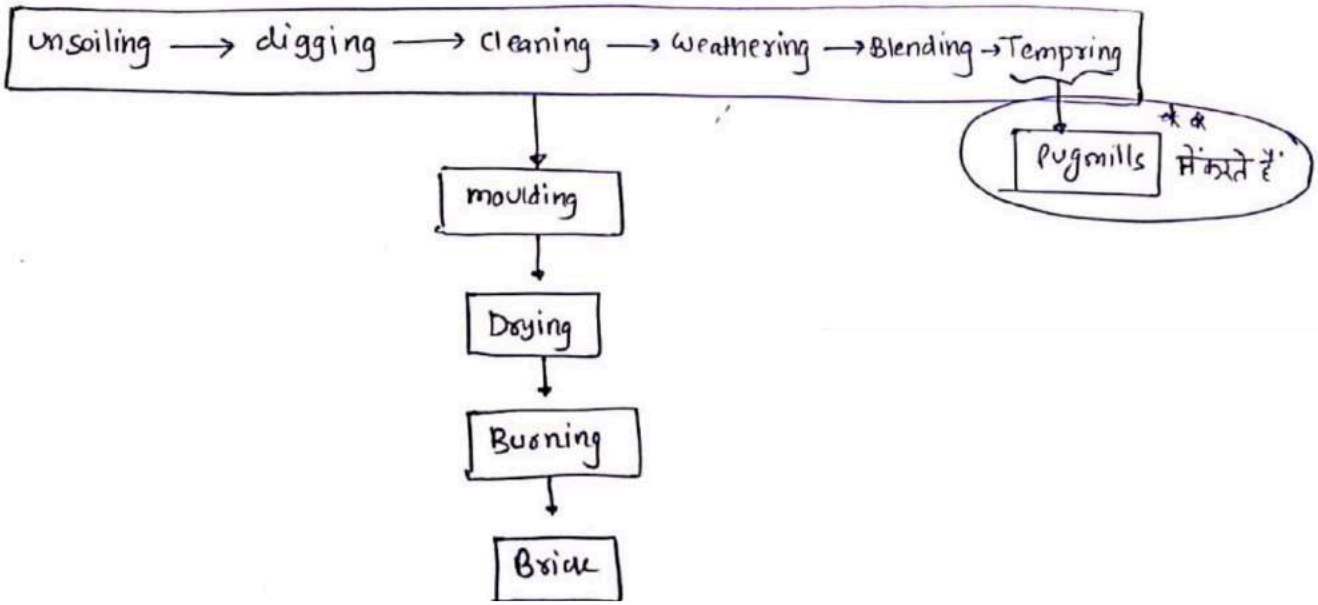


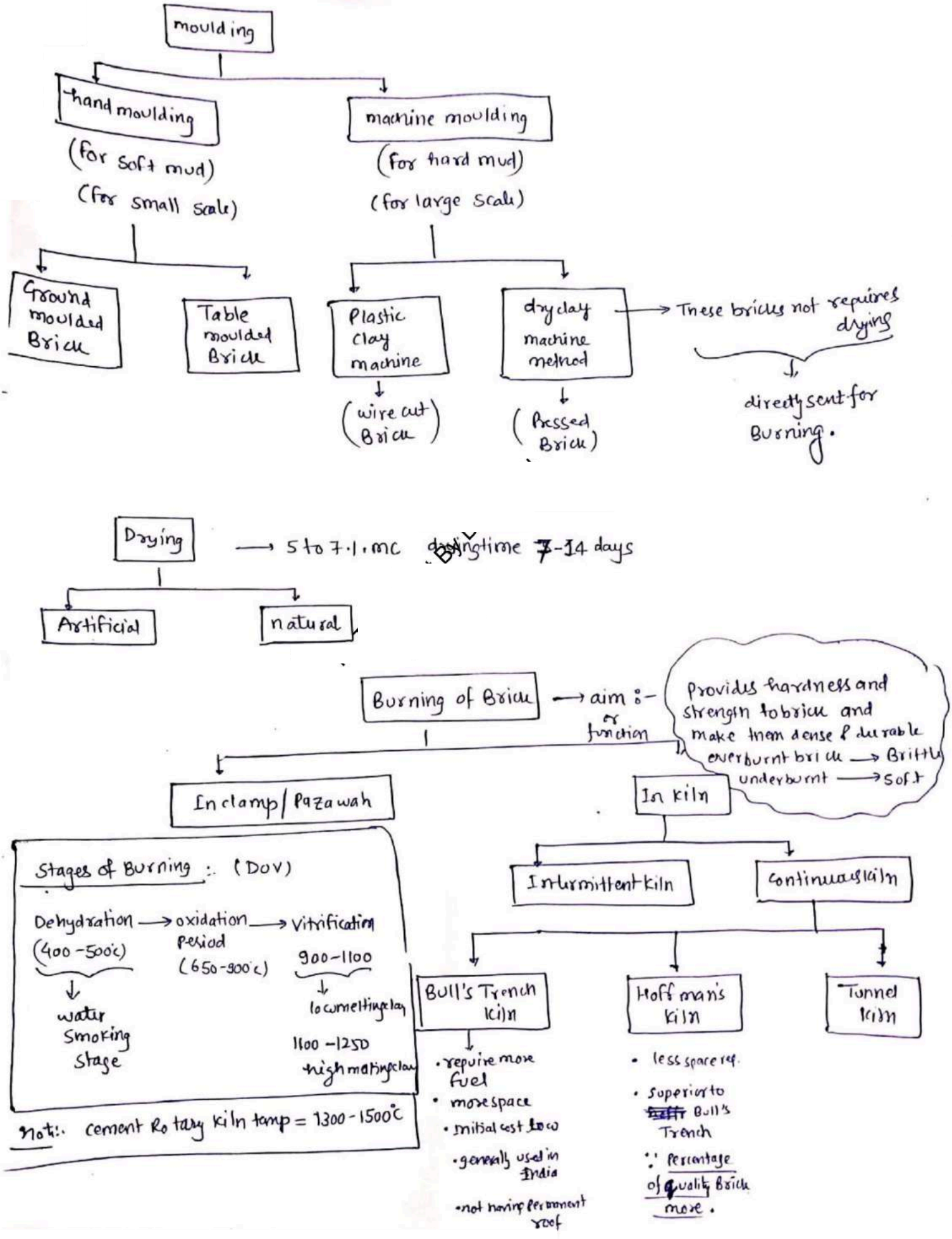
Voussoir (used in arch)

Classification of Bricks :- → Basically Burnt clay brick

First class Brick	Second class brick	Third class Brick
table moulded Brick + Burnt in kiln.	grd moulded Brick + Burnt in kiln.	ground moulded Brick + Burnt in clamp.
• The surface and edges of brick are sharp square Smooth and straight	The surface of these brick is somewhat rough and shape is slightly irregular	not hard and they have rough surface with irregular and distorted edges.
• Ist class Brick has all quality of good Brick	—	gives dull sound when struck together.
• Brick use :- Ist class Superior work of Permanent nature	Use :- where Brick work is to be provided with coat of Plastr	Use :- unimportant and temporary structure.

manufacturing of Brick :-




moulding
hand moulding
(for soft mud)
(for small scale)
machine moulding
(for hard mud)
(for large scale)
Ground moulded Brick
Table moulded Brick
Plastic clay machine
(wire cut Brick)
dry clay machine method
(Pressed Brick)
These bricks not requires drying
directly sent for Burning.
Drying
→ 5 to 7.1. mc
drying time 7-14 days
Artificial
natural
Burning of Brick
→ aim :- or function
Provides hardness and strength to brick and make them dense & durable
overburnt brick → Brittle
underburnt → Soft
In clamp/Pazawah
In kiln
Stages of Burning :- (DOV)
Dehydration (400-500°C) → water Smoking Stage
oxidation period (650-900°C)
Vitrification 900-1100 → low melting clay
1100-1250 high melting clay
Note:- Cement Rotary kiln temp = 1300-1500°C
Intermittent kiln
Continuous kiln
Bull's Trench kiln
Hoffmann's kiln
Tunnel kiln
• require more fuel
• more space
• initial cost low
• generally used in India
• not having permanent roof
• less space req.
• superior to Bull's Trench
∴ Percentage of quality Brick more.

Types of Bond in Brickmasonary

other bond names —
5. facing bond 6. English cross bond
7. Dutch Bond 8. Raking bond
9. Zigzag bond 10. Gardenwall bond
11. Brick on edge Bond.

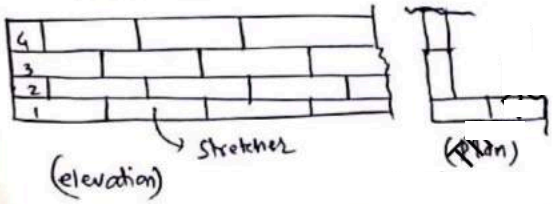
1. Stretcher bond
2. Header Bond
3. English Bond
4. Flemish Bond

① Stretcher Bond :-

Stretcher → Longer face of Brick
→ 19 x 9 cm face in modular Brick

- In this bond, all bricks are arranged in stretcher courses, However care should be taken to break vertical joints.

Use :- construction of half Brick thick partition wall.

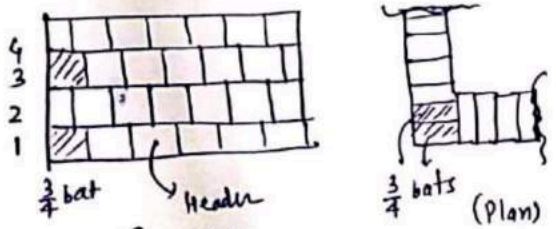


② Header Bond :-

header → shorter face of brick (9 x 9 cm)

- all bricks arranged in the header course

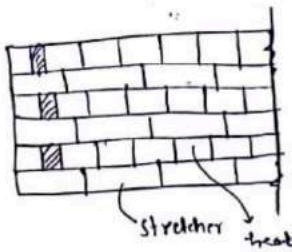
Used :- construction of one brick thick wall.



③ English Bond :- (strongest Bond)

↳ Alternate course consist of header & stretchers.

Uses :- commonly used bond for walls of all thickness



elevation of english bond

- In english bond, to break continuity of joint, queen closer used (cut longitudinally in 2 parts)

④ Flemish Bond :-

In each course comprise of alternate header and stretcher.

- same to break continuity queen closer required.

Use :- for aesthetic point of view

Problem :- needs greater skill for construction.

Types

Single Flemish Bond

- outer face of wall has Flemish look whereas inner face have look of english Bond.

double flemish Bond

- both face of wall have Flemish look.

{ each course consist of alternate header and stretcher.

Different lime process :-

note:- Purest form of limestone → white chalk

Impure form of limestone → kankar

(1) Calcination :-

Limstone $\xrightarrow{\Delta}$ heating in contact with air.

(2) Hydraulicity :-

Property of lime by which it sets or harden in damp places (where there is no circulation of air)

(3) Setting : hardening of lime after it has converted into paste.

Types of Lime

- (<5%) Fat lime / rich lime / white lime / pure lime
- (5-30%) Hydraulic lime / water lime
- (>30%) Poor lime / Impure lime / lean lime

(4) Quick lime or castic lime (CaO) :-

Pure limestone $\xrightarrow[\Delta]{\text{Calcination}}$ Quick lime

Properties :- (a) It is capable of slaking with water.

(b) has no affinity for carbonic acid (H_2CO_3) but great affinity with moisture.

(c) quick lime which comes out from kiln known as lump lime.

(5) Slaking of lime / slake lime :-

- $CaO + H_2O \longrightarrow Ca(OH)_2 + \text{heat} \uparrow$ (quick lime; exothermic rxn)
- when water added to quick lime, chemical reaction happens, due to this quick lime cracks, swell & falls into powder form which is $Ca(OH)_2$ known as hydrated lime. Process → Slaking.

(6) milk of lime :- A thin fluid pourable suspension of slaked lime.

1. Fat lime / rich lime / white lime / pure lime :-

- Impurity (clay) ⇒ <5% (large amount of CaO 95%)
- Slaking → fast (vigrously)
- It hardens very slowly and possesses a high degree of plasticity
- In the presence of air it sets slowly through carbonation (by reabsorbing CO_2 from air)
- Fat lime does not set under water
- Uses → Plastering | white washing

2. Hydraulic lime / water lime :-

- Impurity :- (5-30%) (Atoms clay)
- Stronger than fat lime
- Imp. It sets under water and in thick damp condition with no air circulation.

note:- clay → gives hydraulicity to lime

clay % ↑ ⇒ slaking ↓↓ ⇒ Hydraulicity ↑↑

Uses :- in foundation | under water work

3. Poor lime / Impure lime / lean lime

- Impurity >30%
- Slakes → very slowly.

Test on stones :-

① Acid Test → more performed on **Sandstone**, aim of Test :- is to investigate how much atmospheric action can be resisted by stone.

Process :- Sample of stone 50-100gm → 7 days, 1% HCl → if sharp edges & its surface free from powder → Then good for building material purpose.

note :- if specimen contains $CaCO_3$ then its edge are broken and powder is formed on surface. Such stone has poor weathering resistance.

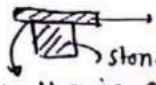
② Attrition test

aim → Predicts rate of wear of stone against the grinding action under traffic. Primarily used for stones to be used in Road construction.

- Test performe in Devil's attrition Test machine.
- % wear = $\frac{\text{loss in weight}}{\text{initial weight}} \times 100$

③ Crushing Test

Sample size = 40×40×40 mm cube. • min no of sample = 3 • put sample 72 hr. in water after test in saturated condition.



load rate = 14 MPa/min

Crushing strength = $\frac{\text{load at failure}}{\text{area of load Bearing failure}}$

④ Crystalline Test

aim → to determine durability or weathering quality of stone.

Sample size = 40×40×40 mm cube min sample = 4

• dry for 72 hr. then weight → 14% sol^{n} of Na_2SO_4 for 2 hr → dry at 100°C & weight change in weight → noted, repeat 5 times.

note :- Although $CaSO_4$ crystallization in the pores of stone causes decay of stone due to weathering, But as $CaSO_4$ has low solubility in water. It is not used for Test.

⑤ Freezing & Thawing Test

Stone in water for 24 hr → @ -12°C freezing machine for 24 hours → put in atmosphere. repeat several time note Behaviour of stones.

⑥ Hardness Test

Apparatus used → Dorry's Testing machine • coff. of hardness = $20 - \frac{\text{loss in weight (gram)}}{3}$

• use → to Judge stone suitability for use

⑦ Impact Test

aim → to determine toughness of stone • The height of drop is increased successively from 1cm to ncm in nth fall when specimen break. here n gives the toughness index for stone.

⑧ micro-scopic Test

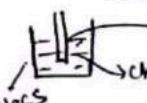
aim → to predict Quality of stone

Properties which are checked (i) Avg. grain size (ii) existence of pore fissure, veins, shakes (iii) mineral constituent (iv) nature of cementing material (v) Presence of any harmfull substance (vi) Texture of stone.

Apparatus → microscope

⑨ Smitch Test

aim → to find presence of any soluble matter



→ if clear water then free from soluble matter

⑩ water absorption Test

aim → to get water absorption.

Saturation coefficient = $\frac{\text{water absorption } (W_2 - W_1)}{\text{total Porosity } (W_4 - W_1)}$ $\frac{W_{24}}{W_5}$

Some Process associated with stones

1- **Quarrying** → Process of extracting natural stone from Rock.

2- **Dressing** → Process of giving a stone Proper size, shape and finish to the roughly broken stones as Obtain from Quary.

3- **Crushing** → Process of obtaining Construction aggregate Produced by mining a suitable rock deposit & breaking the removed rock down to the desired size using crushers.

4- **Seasoning** → Drying of stone from Quary sap, as freshly Quarrsyied stones have moisture.

5. **Stonepitching** :- Interlocking of large stones & Placement of stones on sloped surface.
   → Used for erosion protection of slopy area.

Type of Stone masonary

Rubble masonary	Ashlarmasonary
• use of Irregular shape of stone { ∵ stone's used are hard enough hence proper dressing not possible }	• use smooth face of stone.
• These masonary having rough dressing & having wide joint	• smooth dressing & regular fine joints of 3mm thick

Property of good Building stone :-

(i) Appearance :- good, uniform color

{dark color → more susceptible to weathering}

Imp

(ii) crushing strength = min 100 MPa

(iii) durability - high

(iv) Hardness → if hardness coefficient < 14 → not used in road work

→ min hardness coefficient = 17 for road work

(v) % wear by Attrition Test < 3%

(vi) Resistance to fire

(vii) Specific gravity ≯ 2.7

(viii) water absorption ≯ 0.6%

(ix) Texture :- should be free from cracks, cavity.

(x) toughness index :- by Impact Test

High toughness	19
moderate	13-19
not tough	<13

(xi) stone → sufficient weathering resistance,

Should be well seasoned & facilate dressing.

Stone Quarrying

Process of → extraction of stone

- hand tool
- Channeling machine → By steam or electrically operated
- Blasting → most commonly used for large scale production

Dressing → to increase strength & durability

- to obtain desire appearance
- to reduce transportation and handling cost of stones
- to suit the requirement of stone masonry

Deterioration of stones

1- alternate drying & wetting

2- frost action

3- movement of water / chemical

4- vegetation or organism growth.

Precaution to avoid deterioration :-

(i) Stone placed along their natural bed.

(ii) Proper seasoning before stone use.

(iii) no. of joint should be low
(for this effect, large size stones are used)

(iv) all joints must filled to remove any cavity.

(v) for important Building → use compact silicious stones

* limestone and calcareous stone must be avoided.

* sand stone cemented with silicious binding material may be used.

How to preserve stone :-

(1) By coal tar

(2) linseed oil

(3) Paint

(4) Paraffin

(5) solution of alum & soap

(6) solution of Baryta { when decay is due to $CaSO_4$, this preservation is used } imp

Rocks

Geological classification

Igneous rock
- Form by cooling & solidification of magma/lava.

Igneous rock
- Plutonic (Intrusive)
  - formed beneath earth
  - Ex. Diorite, Granite, Gabbro, Pegmatite, Peridotite
- Volcanic (Extrusive)
  - formed at earth
  - Andesite
  - Basalt
  - Rhyolite
  - Dacite

Ex. of Igneous rock :-
1- Trap
2- Basalt (volcanic)
3- Dolomite
4- Granite
5- Pigmatite
6- Andesite
7- Diorite
8- Gabbro

Sedimentary rock
- form by weathering action of existing rock.

Ex. mudstone, Sandstone, limestone, Lignite, Shale, Gypsum, sand, gravel

Sedimentary rock
- mechanical rock / clastic rock
  - Ex. Sandstone, mudstone, shale
- chemical rock / non clastic rock
  - Ex. limestone
- organic (Biological)
  - Ex. Coal, Chert

Metamorphic rock
- when Igneous & Sedimentary rock undergone considerable change with high Pressure & temperature

name	Type of Rock	Rock after metamorphism
Granite	Igneous	Gneiss
Basalt	"	Laterite
mud stone	Sedi-	Slate
sand stone	"	Quartz or Quartzite
lime stone	"	marbal

Physical classification

Stratified rock
- Rock showed layered structure
- Ex. Sandstone, limestone, Slate

Unstratified rock
- not showing layered str.
- Ex. Granite, Trap, marble

Chemical classification

Calcareous rock
- rock having Calcium carbonate as their main component
- Ex. 1. limestone, 2. marbal

Argillaceous rock
- main component Clay & Alumina
- Ex. 1. mudstone → 2. Slate, 3. laterite, 4. clay

Siliceous rock
- main component Silica
- Ex. Granite, 2. Sandstone → 3. Quartz, 4. trap

5 Basic Parts of Paint (oil paint)

Base | Vehicle (Binder) | (Carrier) | Pigment | Solvents (thinner) | Driers (Plasticizers)

① Base :-

→ principal constituent of paint.

- metallic oxide **
- It makes the paint film opaque and possesses binding property which reduces shrinkage cracks in the film on drying.

Example :- white lead, Red lead, Zinc lead, oxide of Iron, Titanium white, antimony white, Aluminium powder, Lithophone.

② Vehicle (Binder) (carrier)

- It is an oil * to which Base is mixed.
- It holds constituents of paints in suspension and helps spread it over the surface to be painted.
- It imparts durability, toughness and waterproofness and resistance to weathering

Example :- Linseed oil, Poppy oil, tung oil, animal oil

③ Pigments

- fn → used to hide the surface imperfection, and gives desired color **
- They also improve, impermeability of paint film & enhance its resistance to weathering.

name of Pigment	color
Zinc oxide	white
copper sulphate	green
Indigo	Blue
Ivory Black	Black
Burnt siena	Brown
Red lead	Red

④ Solvents (Thinner)

- these are oils used to thin paints & increase the spread *
- They make the paints of workable consistency & evaporate during drying of film.

Example :- Naptha, spirit, Petroleum, turpentine oil

⑤ Driers (Plasticizers)

- these are added in paint for specific purpose
  - → to accelerate drying of vehicle → (as catalyst)
  - → for oxidation
  - → for condensation
  - → for polymerisation

  } of vehicle

Example :-

- letharge
- lead acetate
- red lead
- magnese dioxide

Varnish :-

varnish is nearly homogenous solution of resin in oil, alcoholor turpentine.

varnish objectives :-

(i) To Intensfy or brighten the surface.
(ii) To render brilliancy to the painted surface.
(iii) To protect from atmospheric action.

Ingradient of varnish :-

(i) resin (ii) solvent/thinner (iii) Drier

↓
type of solvent depends on which type of resin used.

Type of varnish :-

(1) oil varnish	• Hard resin used (amber, copal) • linseed oil used & takes more time to dry used → Interior and exterior surface *** most durable varnish ∵ hard resin used
(2) Spirit varnish	• Soft resin used (lac or shellac) • spirit used • not durable, easily affected by weathering action
(3) water varnish	• shellac resin desolve in hot water to which enough quantity of either amonia, borax, soda is added. used * :- for varnishing maps and pictures
(4) Asphalt varnish	• made by disolving melted hard asphalt in linseed oil with a thinner (turpentine oil / Petroleum sprit) * used :- over shop fabricated steelworks.
(5) flat varnish	• materials such as wax, metallic soap on finely divided silica when added to varnish produce a dull apperance on drying.
(6) spar varnish	• It derives its name from its use on spar and other parts of ship * * used → It gives sticky effect in warm weather and is not used Indoors.

Distempers :- are white paints / water Paints

Base: white chalk
thinner: water

- Binder → glue / casein
- color pigment
- cheaper than paints
- distempers washed away when used in exposed surfaces.
- distempers are workable and easy in application

Ind
- most suitable for plastered surface as well as white washed surface of Interior walls.

Putty :- Powdered chalk + raw linseed oil

→ similar texture to clay.

- It has highly plasticity characterstics.
- It is used for filling holes, micro cracks and dofacement in wood.
- It is used in domestic construction and repair as a sealant & filler.

enamels :-

- mettalic oxide +
- oil +
- Petroleum sprit +
- resinous matter.

- The paint dries slowly, but on drying • It produces a hard, Impervious, glassy, elastic Smooth and durable film.

Uses :- Used on doors / windows / metal grills.

Types of paint

cement Paint	• waterbased paint used to Prevent water penetrating reduction of dirt collection, Prevent Fungal & algal growth on interior as well as exterior walls. • durable & water resistant paint • mainly used to decorate exterior surfaces • Ingredient → white Portland cement + lime + some pigments
enamel Paint → vehicle → varnish	is a Paint that air dries to hard usually glossy, finish used for coating which are outdoors. • used for coating surfaces subjected to hard / wear or variation in temperature.
Cellulose Paint	• normally used by ethusiast, first timers or trade professionals when an original finish required. • This paint can produce any flat color & needs only thinners added to it prior to Painting.
Asbestos Paint	→ fireproof paints • Asbestos was very inexpensive and was used as filler in many different products throughout mid industries.

Aluminium Paint :-

- Aluminium Paint is a coating material which is made from a mixture of oil - varnish and (Aluminium pigment) in form of thin flakes.
- It is used for painting wood work and the metal surface.
- It is highly heat resistant and also resistant to corrosive action
- It has brilliant silvery shining texture therefore paint has advantage of being visible in the darkness.

Defects in paint :-

① flaking	• Detachment of paint film from surface. (due to poor adhesion b/w paint & surface)
② chalking	• due to insufficient oil in primer, The formation of white chalking powder on surface ⟶ chalking
③ Cracking	• formation of cracks on painted surface due to Inadquate surface penetration and shrinkage ⟶ cracking
④ wrinkling	when thick layer of paint is applied on horizontal surface.
⑤ Blistering	formation of bubbles like shapes on Painted surface is known as ⟶ blistering • It occures when water vapours gets trapped under the paint layer.
⑥ Blooming	• formation of dull patches on painted surface ⟶ Blooming • due to poor quality of paint and proper ventilation.
⑦ fading	when there is gradual loss of color from the painted surface ⟶ fading • due to reaction of sunlight on pigment of paint.
⑧ Grinning	if the thickness of final coat of paint is very less (thin) the background can be seen clearly ⟶ grinning • due to poor workmanship.
⑨ Running	when painted is very smooth, then paint runs back surface to be and leaves small areas of surface uncovered. ⟶ running

Dhyan 8/3/2020

Based on mode of growth of tree

tree

Endogeneous tree → grow Inward

- limited engineering application

Ex. Bamboo
cane (बेंत)
Palm (ताड़)

exogeneous tree → grow outward → Annular ring Used for Age prediction

mostly used for engg. Application

conifer tree (In Himalaya slope, Thin Jungle)

(soft wood)
(Evergreen tree)

- leaves don't fall till new grows
- needle shape leaves
- cone shape fruits
- distinct annular ring

Ex. देवदार
चीड़
Pine

deciduous tree

(hard wood)
(Broad leaf tree)

- leaves fall in autumn and appear in spring.
- don't show distinct annular ring.

Ex. टीक, महागोनी, शीशम (hardest wood)
ओक, साल, बबूल

(Timber)

Group	E ($\times 10^3$ N/mm^2)
A	12.6
B	9.8 – 12.6
C	5.6 – 9.8

Durability →

		Avg. life
class 1	Highest	> 25 year
2	High	15-25 year
3	moderate	5-15 year
4	Low	< 5 year

Fibre saturation point (FSP)

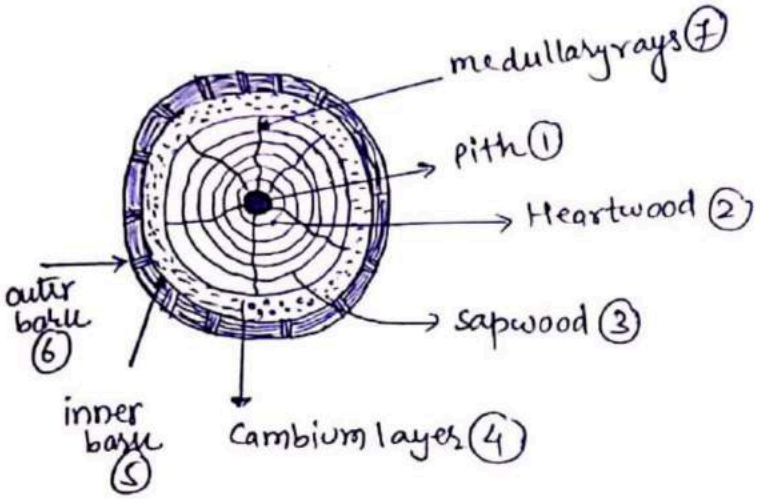
(I) at which all free water removed.

(II) shrinkage rapid.

(III) strength gain rapid.

(IV) cell cavities are empty but cell walls are still Completly saturated.

Cross section of Exogenous Tree :-



(1) Pith (medulla) :-
- Innermost central portion or core of tree
- consist entirely of cellular tissue & it nourishes the plant in its young age.
- As the plant becomes old, pith dies up & decays and the sap is then transmitted by woody fibres deposited round the pith.

(2) Heartwood (Truewood) :-
- inner annular ring surrounding the pitch.
- It indicates dead portion of tree (dead wood)
- It does not take active part in growth of tree
- Impart rigidity to tree, provide strong & durable timber for engineering application.

(3) Sapwood / Alburnum / xylem :-
- outer annual rings between heartwood & cambium.
- light in color & weight.
- It takes active part in growth of tree and xylem carries water & nutrient upto leaves.
- It does not impart any strength.

(4) cambium layer → A thin layer of sap in between sapwood & inner bark
- It indicates portion of sap which is yet to be converted into sapwood hence decides the future growth of trees.

(5) Inner bark (Phloem) :-
- covers cambium layer
- gives protection to cambium layer from any injury • phloem transports food from leaves to roots.

(6) outer bark (Cortex) :-
outermost protection layer, sometime contains cracks & fissures. consist of wood fibre cells

(7) medullary rays :- radial fibre extending from pith to cambium layer.
for
1. to hold annular ring tightly together.
2. to carry sap from outermost to inner part of tree.

← Different timber & its Uses →

Timber name	Property	Use
chir (चीड़)	• moderately hard • decays easily	• used in framing of doors, windows, pattern making etc.
Shisham शीशम or Sissod → (wooden moulds)	• strong & tough • durable and maintain its shape well • easily seasoned • difficult to work with it.	• In high class furniture • In sports goods • For decorative works & carvings
Sal (साल)	• Hard & coarse grained • light in color when freshly cut • resinous and less durable • not suitable for painting	• medicinal use • used in Ayurveda for thousands of years to treat variety of diseases including piles, skin disorder, dysentery etc.
Teak टीक → (Very Expansive) • Life of teakwood door, window → 20 year	• moderately hard • fire resistant & durable (non resinous) • easily seasoned & worked • not attacked by white ants & dry rot • shrink less	• limited to superior work only as it is comparatively very costly. • For ship building furniture, railway carriages, mallits
V. Imp: Plywood	• made from hardwood, softwood or combination of two (some common hardwood → ash, maple, teak oak) Imp • plywood has good and uniform tensile strength both along as well as across the grains. Imp • plywood are veneers (Thin layers of wood) placed one above the other with the direction of grains of succesive layers at 90° to each other • plywood is specified by thickness for common commercial platform. • plywood is obtain by gluing wooden sheets at a pressure of (100–150 N/cm²)	• used for making doors, furniture ceiling, packing cases. • not suited for applications that involves direct impact.

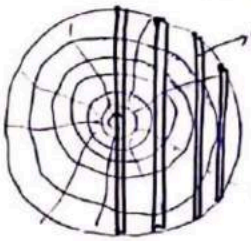
Special points :-

① timber	Use
Alder	furniture, electric guitar
② Asanfora	In musical instrument, heavy construction, furniture flooring
③ mulbery	sport industry
④ Balsa	construction of model aircraft, bridges model Tests.

Sawing of timber

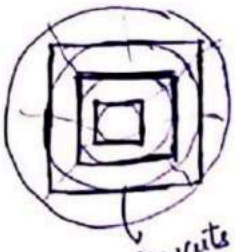
- ordinary or flat or slab sawing → waste min
- tangential sawing → weakest timber
- Quarter or sift sawing
- Radial sawing → Strongest timber

① ordinary / flat / slab sawing :



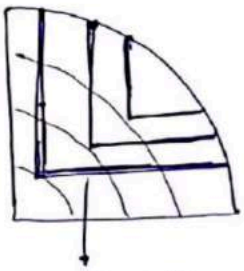
- quick, economical
- saw cuts parallel slices/planks
- planks are liable to warp & twist because of unequal shrinkage of central portion (heart wood) bounded the ends by sap wood, showing higher shrinkage.
- wastage of timber ⟶ Minimum

② Tangential sawing → weakest Timber



- cutting is done tangentially to annular ring and right angle to medullary rays.
- ∵ rays are cut, the section is weak thus planks warp significantly on drying.

③ Quarter / sift sawing :-

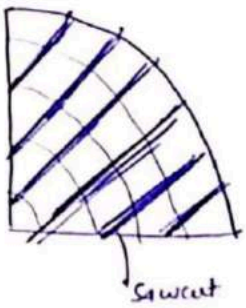


- First log is cut into 4 quadrants
- each quadrant is further sawn by plain, tangential or radial sawing.

It wears better and shrinks more evenly.

④ Radial sawing : → Strongest Timber

- sawing is done parallel to rays and ⊥ to rings



- Radial sawing will produce the strongest timber ∵ medully rays are not cut as sawing is done parallel to rays.
- ∵ strongest timber - hence planks are suitable for hard wearing and abrasive action.

fire resistance of timbers :-

- with respect to fire resis-tance

timber

- refractory timber → non resinous (does not catch fire easily) Ex. साल, टीक
- non refractory timbers → resinous (catch fire readily) Ex. चीड़, देवदार

methods to make timber fire resistant

Sir Abel's process

1- clean the timber
2- coat with dilute solution of sodium silicate (Na_2SiO_3)
3- cream like paste of slaked lime is applied on it
4- finally concentrated solution of silicate of soda is applied on timber surface.

Application of special chemicals

"Antipyrine"
1- Ammonium sulphate
2- Borax
3- Zinc chloride
4- Boric acid

- A solution of special chemicals called antipyrine issued to coat the timber to make it more fire resistant.
- when tumprature rises, they either melt or give off gases which hinder combustion.

Seasoning of Timber :-

- Process by which moisture content in a freshly cut tree is reduced to a suitable level, by doing so the durability of timber is increased.

objective of seasoning :

1- To reduce the weight
2- to increase strength, durability, workability
3- to allow the timber to burn easily if used as fuel
4- remove sap from timber
5- Reduce tendency to split & decay
6- Reduce shrinkage & warping after placement in structure.

note:- moisture content in well seasoned timber = 10-12%.

method of seasoning :-

(A) natural seasoning (air seasoning)

- very cheap • very simple • slow process
- Basic principle is to stack the timber so that plenty of air circulate around each piece, The timber is stacked with wide spaces between each piece horizontally and with strips of wood between each layer ensuring that there is vertical separation too. and natural air is allowed to blow in between the timber stack to bring moisture content 20-25%

disadvantage :- drying of different phases may not be uniform.

(B) Artificial seasoning :-

In this method timber is seasoned in a chamber with regulated heat, controll humidity and proper air circulation. & therefore specific conditions for different species can be maintained.

1. water seasoning (Boiling) :

- timber is immersed in water
- water boiled for 3-4 hrs, then dried slowly
- Instead of boiling water hot stream may be circulated on timber, The process of seasoning is fast, but costly.

2- Kiln seasoning (kiln → air tight chamber)

- timber to be seasoned is placed inside kiln then fully saturated air with a temp. 35-38°C is forced inside it
- The heat gradually reaches inside timber, relative humidity is gradually reduced and temp is increased and maintained till degree of moisture content is achieved

kiln

- Stationary kiln
- Progressive kiln

- In progressive kiln, the carriages carrying timber travel from one end to other end of kiln, hot air is supplied from discharging end so that temp. increases is gradual from charging end to discharging end. This method of seasoning used on large scale (chem)

(3) chemical seasoning : Used solution of suitable salt

- immerse timber in salt solution then dried in kiln.

Preliminary treatment by chemical seasoning ensures uniform seasoning of outer & inner parts of timber.

(4) electrical seasoning :-

high frequency AC current pass through timber. Resistance to electric current is low, when moisture content is high. measure of resistance can be used to stop seasoning at appropriate level. It is costly process.

Preservation of timber :-

objective 1- To increase life of timber

2- to make timber structure durable.

3- to protect the timber structure from attack of fungi & insect.

Requirement of good preservative -

1- cheap, durable, easily availability

2- capable of covering large area with small quantity.

3- free from unpleasant smell.

4- Penetrating power into wood should be high (at least for a depth of 6-25mm)

5- High resistance to moisture and dampness.

6- should not be easily washed away by water.

7- Should not corode metal with which it comes into contact.

Types of preservatives :-

1- Ascu Treatment :- given by FRI, dehradoon.

1- $AS_2O_5 \cdot 2H_2O$ → arsenic pentaoxide
3- $CuSO_4 \cdot 5H_2O$ → cupper sulphate
4- $K_2Cr_2O_7$ → potasium dichromate.
or $Na_2Cr_2O_7 \cdot 2H_2O$ Sodium dichromate.

- gives protection against (white ants)
- surface treated with this preservative can be painted, Polished, varnished, waxed.

2- chemical salts :- $CuSO_4$, $HgCl_2$, NaF, $ZnCl_2$
↓
odourless, non inflamable

3- coal tar :- fireresistant, cheap
↳ no paint after this.

4- creasote oil → Best antiseptic **
(tar and oil type)
↳ Black or brown liquid.

- doubles the life of timber (Ex. railway sleeper)
- should not use for interior surface of dwelling houses, food stuff storage premises in underground installation and near inflamable source.

5- oil paints :- apply 2-3 coats of oil paint.
↳ preserve timber from moisture and make it durable.

6. Solignum paints :- Preserve timber from white ants
↓
highly toxic in nature
↳ they can be mixed with color pigments and applied in hot state with help of Brush.

type of Preservative	Ex.
tar oil type	creasote
organic solvent type	dieldsin, DDT
water soluble type (fixed)	chromated zinc chloride
water soluble leachable type	Borax zinc chloride.

Treatment methods of timber :

1- surface application → Brushing, spraying, dipping

2- Hot and cold process (hot & cold open tank treatment)

3- Bouchelie process

4- Diffusion process

5- Pressure or pneumatic process

- fuel cell or Bethel process
- empty cell process
  - Lowry method
  - Rueping process

6- charring process.

v.v.imp- **Defect in timber**

- defect due to fungi
- defect due to seasoning
- defect due to Insects
- defect due to natural force
- defect due to conversion

1:- defect due to fungi (microscopic plant organism) :-

fungi Attack when

- moisture content > 20%
- \+
- Presence of air and warmth for growth of fungi

- both condition should satisfy for attack by fungi

note :- 1- Bacteria don't cause serious damage except discoloration.
2- decay process proceeds more in low density (∵ soft texture and higher moisture content)

Some of the defects caused by fungi →

1. Blue stain (sapstain) :- sap of wood color → Blue (due to attack of fungi)

2- dry rot (never in standing tree)

Imp → attack on sapwood by fungi for feeding and convert into dry powder.

- It is aggrevated due to dry spell after heavy rain.

Causes :-

1- absence of sunlight, Presence of dampness, Presence of sap, stagnant air & warmth.
2- where there is no circulation of free air (ie non ventilated Basement, damp situation (toilet, kitchen)
3- easily attack on unseasoned soft wood
4. By charring, Painting, tarring of unseasoned timber.

Remedy :- Use well seasoned timber free from sap.

3- wet rot

- wet rot fungi causes chemical decomposition of timber convert wood into greyish Brown powder

cause :-

Imp 1- Alternate drying & wetting condition { shrinkage & swelling occur
Imp 2- Improper seasoned timber exposed to rain & wind.

Remedy :- wood cover by tar / Paint to proted against moisture.

4- Brown Rot (Grey Rot) :- Brown rot fungi Breakdown cellulose * & fumicellulose compands from wood & attains brown color.

5- white rot :- attack on lignin of wood and wood attains white mass consisting of cellulose.

6- Heart rot :- when decay of wood at the centre of trunk and Branches due to fungi attack over heart wood.

- It reduces strength, sound → hollow (when hit by hammer)

Very Imp :-

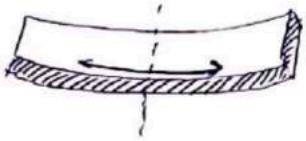
Rot :- Rot in timber is decomposition / putrifaction generally caused by damp atmosphere. which causes emission of gases mainly carbonic acid & hydrogen.

defect due to seasoning :-

if seasoning is not uniform, the converted timber may wrap & twist in various direction.

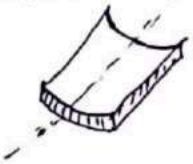
1- spring :-
(crook or free side bend)
→ curvature of timber in plane of its wide face.

2- Bow :- curvature formed in length direction.



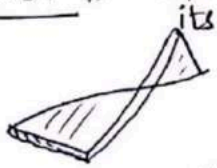
cause by grain irregularity in board, can be eliminated by proper stacking.

3- Cup :-
- curvature of timber in transverse direction.



caused by unequal shrinkage in radial and tangential direction

4- Twist :- Spirally distortion along its length. (curvature both along the length & width



5- split

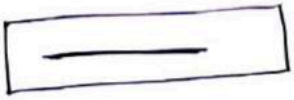
- separation of fibre along grain extends from 1 end of plank to other end.

6- Wrap :- Timber has curvature along length and in the plane.

(when piece of timber has twisted out of shape)

caused due to uncontrolled and non uniform loss of moisture from wood

7- cheeks :- It is a crack which separates fibre of wood due to rapid drying, It does not extend from one end to another.



- Small cracks appearing at the ends of boards.

8- Honeycombing :- due to stress developed during drying, various radial & circular cracks develop in the interior portion of timber, which resembles with honeycomb texture.

Some other defects due to seasoning
- Radial shakes (radial cracks ⊛
- case hardening.
- collapse.

defect due to Insects :-

termites (white ants) | Beetles | marine borers

these eat wood & weaken the timber

- termites make tunnel inside the timber in different direction at centre leaving outer shell intact, therefore timber piece may look sound till it completly fails.

note:- Teak, sal ⟶ can resist white ant (termite) attack.

defect due to conversion :-

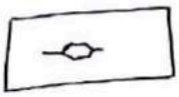
1- chipmark :- ⟶ marks placed by chips on finished surface of timber

Reason → due to pointed parts of sawing machine.

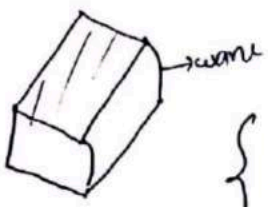
2- diagonal grain :- Presence of diagonal mark over straight grain

Reason ⟶ Improper sawing.

3- Torn grain → when tool falls ⟶ small depression on finish surface.



4- Wane - due to unsound milling practice, corners of wood section having some part of bark



{ Basically presence of original round corner }

Defect due to natural force :-

coarse grain, wind rain

knot | foxiness | Druxiness | twisted fibre | upset (rupture) | shake | burl (Rindgalls) or excrescence

1- knot :-

knots are formed in the timber, when tree loose its branch.

- In the sawn pieces of timber, the stump of fallen branches appears as knots. knots are dark and hard pieces
- Grains are distorted in this portion. knots are source of weakness.

2- Foxiness :- red or yellow tinge in wood 'or' reddish brown stains/spots around the pith of tree discoloring the timber.

Reason :- due to poor ventilation during storage of timber.

3- Druxiness :- white decayed spots formed by fungi

4- Burl (excrescence) :- formed when tree receives shock or injury in its young age.

{ due to its injury, growth of tree is completely upset and irregular projections appear on body of timber.

- Rindgalls → . due to unsuccessfull attempts at the formation of branches.
  → these are distinct outgrowth resulting due to swelling caused by growth of layers of sap wood over wounds after branch is cut.

5- Rindgalls :- → same as burl

6- upset/ruptures :-

- when wood fibers are injured by crushing or compression. (during growth or Bad felling of tree)

7- Twisted Fires :-

- caused by twisting of the young trees constantly in one direction by fast blowing wind.

Note:- Plank sawn from tree with normal growth are stronger than the one sawn from trees with twisted fibre.

8- Wind cracks :- if wood is exposed to atmospheric agencies, then cracks on the outside of a log due to shrinkage of the exterior surface.

Such shrinkage results into crack, These are not very deep crack.

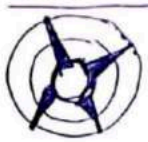
9- Shakes →

Shakes :- • It is longitudinal separations (cracks) in the wood between annual rings

• This length wise separation reduce the allowable shear strength without much effect on compressive & tensile strength.

• wood Appearance → undesirable

① Heart Shake :- → due to shrinkage of heart wood when tree is overmatured.



• crack start from pith & run towards sapwood.

• These are wider at centre and diminish outwards.

② Star Shake :- → cracks wider at circumference (bark) and diminishing towards centre of the tree.

• cracks arises from severe frost and fierce heat of sun.

• Star shakes appear as the wood dries below fibre saturation point.

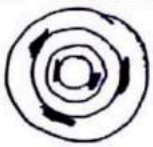
• It is fault leading to separation of log into no. of pieces when sawn.

③ Radial Shake :- → similar to star shakes but they are fine, irregular, numerous

• split starts from bark and sapwood and extends to heartwood & pith

• occures when outer tissue dry at faster rate than inner ones, this defect can also occure during seasoning process due to excessive heat of sun or cold of frost

④ Cupshake :- → appears as curve split which partly or wholly separates annual ring from one another.



↳ caused due to excessive frost action or non uniform growth.

⑤ Ringshake :- when cup shakes covers the entire ring.

Admixture

- **Chemical admixture**
  - (i) Plasticizer
  - (ii) Accelerator
  - (iii) Retarder
  - (iv) Air entrainer

  chemical admixture are added at the time of mixing of concrete.
- **mineral admixture**
  - (i) Pozzolonas
  - (ii) Blast furnace slag
  - (iii) Silica fume
  - (iv) Risk husk.

  mineral admixture are added after grinding of cement clinker, they replace the cement by 10-70% by mass.

SMF

Antibleeding agent - $Al_2(SO_4)_3$

Use of admixture :-

(i) to reduce water content without changing ~~water content~~ workability.

(ii) to increase workability without changing water content

(iii) 1 & 2 both

(iv) to accelerate the initial set of concrete (to speed up the rate of strength development at early ages

(v) to decelerate initial set of concrete

(vi) to improve durability.

(vii) to reduce permeability

(viii) to decrease density of concrete

(ix) to decrease/reduce segregation & bleeding.

(x) to Improve pumpability

Admixture	Property / use	example
Plasticizer	reduce water content (→ about 10%) (Improve workability of fresh concrete for given w/c ratio	(i) lignosulphonic acid (ii) Hydroxylated Carboxylic acid (iii) polyglycol esters
Superplasticizer	reduce water content about 20-40% (workability greatly enhanced) by dispersion of cement particles	(i) SMF : sulphonated melamine formaldehyde (ii) SNF : napthalene sulphonate formaldehyde (iii) MLS : modified lignosulphate
accelerator	accelerate rate of setting or early gain of strength of concrete	(i) $CaCl_2$ (<2%) (ii) NH_3, K → salt NaCl → KOH Na_2SO_4 → K_2SO_4 NaOH
Retarder	longer setting time, slower initial strength gain	Calcium sulphate, sugar, cellulose
air entrainers air entrainment in concrete incorporating millions of noncoalescing air bubbles which acts as a flexible ball bearing and modify	• improved resistance to damage from freezing & thawing. • increase workability • increase resistance to chemical attack • decrease in segregation, bleeding, permeability • reduce strength → hence suitable adjustment in mix design for achieve required strength.	(i) Wood resin (ii) vegetable oil (iii) animal/vegetable fat (iv) olive oil (v) Aluminium powder

Durability of concrete :-

It is defined as its ability to resist weathering action, chemical attack, abrasion or any other process of deterioration.

factor affecting durability.

Physical	chemical	others
(I) Temp.	(I) Sulphate attack	(I) cinder → Pyroclastic material (extusive Igneous rock)
(II) moisture	(II) Alkali aggregate reaction	(II) Vinegar → Promotes acid attack
(III) freezing & Thawing	(III) chloride ion attack — corrosion	
(IV) Ice-melting	(IV) Carbonation	
	(V) Acid attack	

(I) Acid attack :- • when concrete exposed to acid, concrete disintegrate depending on the type and concentration of acid.

• The most vulnerable part of cement hydrate is $Ca(OH)_2$, but CSH gel can also be attacked.

• if acids are able to reach the reinforcing steel through cracks / porosity of concrete then corrosion can occause which will cause cracking.

(II) Sulphate attack :-

• Sulphate in solution form, finds entry into porous concrete and react with the hydrated cement products.

• Calcium Aluminate hydrate (C-A-H) react with sulphates and produce Sulphoaluminate which results in increase in volume of solid phase which can go upto 227 %, a gradual disintegration of concrete takes place. This phenomenon is known as sulphate attack.

• This can be controlled by →

- Sulphate resisting cement
- Quality concrete
- Pozzolona
- High pressure steam curing

(III) Alkali Aggregate rxn (Alkali attack)

• Alkali present in cement reacts with reactive silica contained in aggregate • as a result Alkali silicate gels of unlimited swelling type are formed.

Progressive manifestation of swelling results in disruption of concrete with the spreading of pattern cracks and eventual failure of concrete structure. this Phenomenon ⟶ (Alkali attack)

---

⑤ Frost Action :-

- Concrete affected due to being Permeable or by temp. below 0°C because of expansion of absorbed water on freezing ice builds up in large pores causing large expansion in local areas cause disintegration.

favorite condition for frost action :-

1- repeated freezing & thawing and use of deicing salts

2- low temp ⟶ resulting in freezing to greater depth in Concrete.

Durability criteria :-

Exposure category	Description	Min RCC grade (M)	min PCC grade (M)	min nominal cover	RCC min (cement (KG/m3)	max. water cement ratio
mild	• Protect against weather or aggresive condition (except if located in coastal area)	20	—	20	300	0.55
moderate	• sheltered from severe rain • continuously in water • non aggresive soil or grd. water • sheltered from saturated salt air in coastal area	25	15	30	300	0.50
Severe	• Exposed to severe rain • Alternate drying wetting • severe condensation • completely immersed in seawater • Exposed to coastal environment	30	20	45	320	0.45
very severe	• Sea water spray • contact with or buried under aggressive soil or grd water	35	20	50	340	0.45
Extreme	• members intidal zone • members in direct contact with liq/solids aggresive chemical	40	25	75	360	.40

Imp note:-

(i) mild ⟶ if $\phi_{main} \leq 12$ mm then cover reduced by (5mm)

(ii) severe, very severe ⟶ if $\geq M35$ then cover reduced by (5mm)

7/3/2020

Permissible limits for solids as per IS 456

organic	200 mg/lt
sulphate ($as SO_3$)	400 mg/lt
chlorides (as Cl)	500 → for RC work
	2000 mg/lt → concrete work not containing embeded steel
suspendid solids	2000 mg/lt
Inorganic	3000 mg/lt

Impurities in mixing water of concrete:-

1- Carbonates of Na, K → cause quick setting

2- Bicarbonates of Na, K → may either accelerate or retard the setting

] high concentration of these salts will materially reduce the concrete strength.

3- chlorides

4- Sodium anhydrides (max. 3000 ppm)

5. Calcium chloride (max. 2% by weight of cement in Prestress concrete)

6- Sodium sulphide

7- Sodium hydroxide

8- salt & suspended solids

9- TDS

10- Organic matter

Proportioning of concrete :- → Process of selecting quantity of cement, sand, coarse agg. and water.

✓ In concrete to obtain desired strength & quality, proper proportioning need to be ensured.

Aim :-

(i) Desired workability
(ii) Desired strength
(iii) desired impermeability (water tightness & resistance to penetration of harmful chemicals from outside)
(iv) desired durability. (to resist environmental attack)
(v) cost of material & labour required should be Min.

method of proportioning concrete :-

(i) **Arbitrary method** :- (on the basis of past experience)

the general expression for the proportion of cement, sand & CA is. 1 : n : 2n by volume.

Ex. 1 : 1 : 2 and 1 : 1.2 : 2.4 → for very high strength

1 : 1.5 : 3 and 1 : 2 : 4 → for normal work

1 : 3 : 6 and 1 : 4 : 8 → for foundation & mass concreting works

Grade of concrete	nominal mix proportion
M10	1 : 3 : 6
M15	1 : 2 : 4
M20	1 : 1.5 : 3
M25	1 : 1 : 2

(ii) **Is code method** (Recommended method)

- The grades of concrete lower than M20 should not be used in RC works.

(iii) **fineness modulus method** :-

fineness modulus → Empirical factor obtain by adding the cumulative % of aggregates retained on each of the standard seive ranging from 80mm – 150μ & dividing this sum by 100.

fineness modulus ↑ ⇒ coarser particle ↑

- fineness modulus is an index no. which is roughly proportional to the avg. size of the particle in the entire quantity of aggregates.

type of sand	fineness modulus range
fine sand	2.2 – 2.6
medium sand	2.6 – 2.9
coarse sand	2.9 – 3.2

Aspect fineness modulus of mix design

$$P = \frac{x - z}{z - y} \times 100$$

(x → CA, y → FA)

Proportion of fine aggregate to coarse aggregate.

x → fineness modulus of coarse aggregate (CA)

y → ——— fine ———

z → ——— combined ———

'or'

if Proportion of fine Agg = P

——— coarse = 1 − P

$$\therefore FM_{combined} = \frac{P(f_{FA}) + (1-P)f_{CA}}{1}$$

P = 1/4 = 0.25 = 25%

• Aspect fineness modulus method →

maximum quantity of water added in 1st batch →

$$0.3P + 0.1Y + 0.01Z = \frac{W}{C} \times P$$

($P \to C$, $Y \to FA$, $Z \to CA$)

P → Quantity of cement by weight

Y → ——— fine aggregate ———

Z → ——— coarse aggregate ———

W/C → water ratio method.

(iv) minimum void ratio method :-

In this method quantity of sand used such that it completely fills the void of coarse aggregate and cement quantity. This method does not give satisfactory result.

• In actual practices, the quantity of fine aggregate used in the mix is about 10% more than the voids in coarse aggregates.

(v) maximum density method :-

$$P = 100\left(\frac{d}{D}\right)^{1/2}$$

% of material finer than diameter 'd' by weight

d → max. size of fine aggregate.

D → max size of coarse aggregate.

• In this method, a box is filled with varying proportion of fine and coarse aggregate the proportion which gives heaviest weight is then adopted.

(vi) water cement ratio method

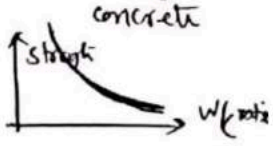
28 days concrete strength

$$S = \frac{A}{B^x}$$ → w/c ratio

Aspect Abram's Law

• lower the w/c ratio, higher the strength of concrete

* Strength $\propto \frac{1}{(w/c)}$



⇒ The optimum water cement ratio for the concrete of required compressive strength is decided from graph & Expression developed from various experiments.

Defect in concrete :-

① Cracks :-

acceptable limit = 0.1 - 0.3 mm

As per IS-456

mild exposure category	= 0.3 mm
moderate "	= 0.2 mm
≥ severe "	= 0.1 mm

Reasons :-

1- use of unsound material
2- Excess water (w/c ratio → too high)
3- Bad joint technique
4- freezing & Thawing
5- Thermal effect
6- early loss of water → shrinkage cracks or shrinkage

② Crazing :-

- development of a network of fine random cracks on surface of mortar caused by difference in shrinkage b/w surface & interior.

How to avoid crazing

1- Use earth moist mix
2- Use plastic mix (low w/c ratio)
3- remove the cement skin to expose the aggregates.

note :-

Shrinkage :- It is used to describe the various aspect of volume-changes in concrete due to loss of moisture at different stages due to different reasons.

Shrinkage → increases "Bond strength"

Plastic Shrinkage

- due to loss of water by evaporation from surface of concrete.
- The volume change is high for concrete having high cement content.

Drying Shrinkage

- due to loss of water in the gelpores.
- Higher cement content leads to higher drying shrinkage.

Thermal Shrinkage

- The seasonal & daily variation of temp. causes concrete to shrink & expand.

Carbonation Shrinkage

- due to CO_2 present in atmosphere, reacts in presence of $Ca(OH)_2$ and forms $CaCO_3$.
- The new product $CaCO_3$ is less in volume hence shrinkage takes place.

③ efflorescence :-

- appearance of white patches on the surface of concrete member.

Reasons :-

① Use of poorly washed aggregate

② Salty water used

Remedies :- coat surface by waterrepellent

effect of segregation on concrete

① Strength reduces

✓ ② Honeycombing in concrete *

③ Porous layer in concrete

✓ ④ Sand streaks in concrete *

⑤ Segregated concrete does not give a homogeneous mix throughout the structure.

⑥ Excessive plastic shrinkage

④ segregation :-

- separation of constituent matrial of concrete because they have different specific gravity.

'or'

Seperation of coarse aggregate from concrete during transportation → segregation

Causes of segregation :-

1- Excess water in concrete mix.

2- Dropping concrete from height

3- Badly proportioned mix (Poor aggregate grading)

4- Use of larger proportion of max. size aggregate.

(In this case coarse aggregate will settle down at bottom of mix)

5- overvibration

6- extra floating and tamping.

note:-

* Honeycombing in concrete :- Honeycombs are hollow spaces and cavities left in concrete mass on surface or inside the concrete mass where concrete could not reach.

Reasons :

1- Improper vibration during concrete

2- Less cover to steel bars

3- Use of very stiff concrete

✓✓ 4- Segregation of concrete

5- Presence of more percentage of bigger size aggregate in concrete.

note:- Sand streaking in concrete :-

- a streak of exposed fine aggregates in the surface of formed concrete caused by bleeding.

{ a form of segregation in which water comes upto surface. }

How to avoid sand streaking

1- Reduce water content
2- Add air entrained admixture
3- Increase cement content
4- Adding flyash as a supplement.

⑤ Bleeding :-

- seperation of water from a freshly mixed concrete to the top surface → Bleeding.

{ because of low specific gravity }

Reasons :-

(i) highly wet concrete
(ii) Bad proportion mixes.
(iii) Excessive vibration imparted to concrete to achieve full compaction.

⑥ "Laitance"

↳ when water comes up with cement particles to the surface it is called "Laitance".

- capillary action works here.

Bulking of sand :-

(I) The presence of moisture in sand increases the volume of sand.

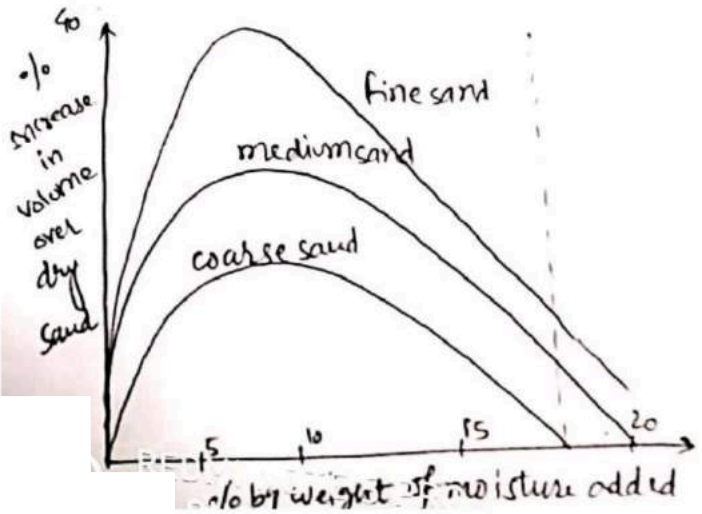
(II) Bulking is due to the fact that →

"moisture causes film of water around sand particles which increases the volume of sand."

(III) The moisture exerts surface-tension and keeps every particle away from each other denying any point contact between them

(IV) The finer the material more will be bulking for given moisture content.

(V) when moisture content is increased by adding more water, the sand particle pack near each-other and amount of bulking of sand decreases.



note:- It is noted from figure →

Increase in moisture content of 5-8% the increase in volume can be as much as 20-40%

significance of Bulking →

(I) Bulking affects volumetric proportion of sand, and hence if suitable allowance is not made for it, It will increase cost of cement and mortar

(II) It will lead to under sanded mixtures which are very difficult for working & laying.

Determination of % of Bulking of sand :-

1- take moist sand in measuring cylinder say h_1.

2- add water in cylinder & stirred by rod

3- as the volume of flooded (inundated sand) sand is same as dry sand, it will offset the bulking effects.

4- The level of sand is again noted (h_2 say)

5- $$\% \text{ Bulking} = \frac{h_1 - h_2}{h_2} \times 100$$

Grading of aggregates :-

(i) Grading zones of sand (Fine aggregate) :-

(i) The sand must be proper gradation because that it will have less voids and hence the cement required will be less. such sand will be more economical.

(ii) As per IS 383-1970 :-

There is 4 gradation mainly according to 600μ sieve percentage passing criteria.

	fineness modulus
Zone - 1 → coasest sand	4 - 2.7
Zone - 2	3.4 - 2.1
Zone - 3	2.8 - 1.7
Zone - 4 → finest sand	2.2 - 1.3

none need to remember

- fineness modulu increases with increase in size particles.

*from grading zone 1 to 4, the fine aggregate becomes progressively finer. then ratio of fine to coarse aggregate should be progsessively reduced.

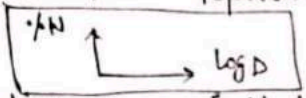
(iii) An aggregate falls in a particular grading zone if its % passing through 600 μ sieve falls in its range and is not allowed to fall outside the limits of other sieve by more than 5%.

(iv) The permissible limit for crushed stone on 150μ sieve is increased to 20%, but it doesnot affect 5% allowance permitted to other sieve sizes.

② grading of coarse aggregates :-

① for coarse aggregate the grading is expressed in terms of % by weight retained on or passing through a series of sieves taken in order 80mm, 40mm, 20mm, 10mm, 4.75mm.

② A curve called grading curve is made showing cumulative % material passing sieves coordinate with the sieve opening to the logarithm scale represented on abscissa.



- grading curve indicates whether the grading of given sample is

③ The main points governing the desired aggregate grading →

(A) surface area of aggregate
(II) relative volume occupied by Aggregate
(III) workability of mix
(IV) resistance to segregate.

(IV)

The smaller size of Aggregate, the greater is the surface area hence to fill the voids with minimum amount of fine-aggregates, the aggregate size should be as large as possible.

Stages of concrete production

Batching → mixing → transporting → Placing → compacting → curing → Finishing

① Batching of material

measurement of materials

- aggregate, cement, water or concrete material
  - accuracy → ±3% of batch quantity
- admixture
  - accuracy ⇒ ±5% of batch quantity

Batching of concrete

- volume batching (by volume)
  - (for small jobs only)
  - Bulking of sand is taken into account.
- weight batching (by weight)
  - (for important works)
  - no need to take effect of bulking of sand.

note:- ① for smaller works manual batching is done.

② for large size works bucket equipment weigh used.

③ now a days automatic batching plants ranging from small to large capacity are available.

note:-

weight batching →

The correct dry weight of each size range of each material is calculated from their actual weight and then weight of water is measured after making compensation for absorbed & surface water.

② mixing of material :-

aim → to obtain homogeneous uniform color and consistent concrete of desired strength.

relaxation approx 20

Asper IS:456 concrete mix time → 2 min.

- mixtime ↑ → uneconomical concrete
- mixtime ↓ → poor quality of concrete.

concrete mixing

- hand mixing (small jobs)
- machine mixing → for large job, where faster rate & better quality required.

- Batching Plant
- concrete mixer or
  - drum type mixure
    - Tilting mixer (T)
    - nontilting mixer (NT)
    - Reversing mixer (R)
  - Pan type mixure
    - efficient in stiff mix
    - mix time → 30 to 60 sec

L Tilting mixer :- (T) type

- use for large construction works.
- when agg. size > 75 mm use

85 T, 100 T, 140 T, 200 T → Batch capacity in (litre)

2- nontilting type mixer (NT) :-

- suitable for small works
- when agg. size ≯ 75 mm

200 NT
280 NT
340 NT

3- Reversing mixer (R)

forced action type mixture

- for large size work
- → horizontal nontilting type drum with 2 sets of Blade.

200 R
280 R
400 R

note:- Paving mixer → for concreting of rigid pavement

27 E, 34 E → Paving mixer

→ nominal volume of mixed concrete in (cubic feet) in one batch.

③ Transportation of concrete :-

Imp

noti:

mixing + transportation + placing + compaction ⩾ 30 min. (IST of OPC)

methods :-

① **mortar pan** :- • labour intensive method
• use for small work
• there are no chance of segregation
• In hot weather more loss of water may happen.

② **wheel borrow / Hand buggies or hand cart**

→ Used on grd level, road construction.
• segregation can occure if done on rough roads.

→ Power buggies → (Use of power to move)

③ **Tower bucket** :- vertical hoist in form of tower erected. and wheel borrow moves within guide rails.

advantage :- initial cost → less and can be used in congested area as It requires less space.

④ **Bucket & ropeway** :-
• Used for works in valley over high piers and long dam sites.

⑤ **Truckmixer and dumper** :-
improved & better method for long road concreting.

noti:- if long distance involved, agitator should be used (max. 1.5 hr distance)
(enroute agitation to prevent it from segregation)

⑥ **chute** :- where concreting in deep location (at higher depth)
• Concrete discharge through steel Shaft called chute.

⑦ **Skip & hoist** :- widely used for high rise structure. concrete is fed into skip which travels vertically on rails like a lift.

⑧ **concrete pump & pipeline**
- Piston pump
- Pneumatic pump
- squeeze pump Pressure

→ Suitable for limited space where large quantity to be Poured.

⑨ **Transit mixer** : Particularly used in RMC Plant
Capacity 4-7 m³

⑩ **Belt conveyor** :- where concrete should be transported continuously and inaccessible area

Advantage → uniform flow of concrete, High capacity

disadvantage → • segregation chances
• Badly affected by severe hot or cold environment.

④ Placing of concrete :-

note:-

1- for dry mix in hot weather
- 0.30 - 1 hr allowed

2- for wet mix in cold weather
- several hrs allowed

Imp
3- max. fall allowed - 1.5 meter {As per IS:456}

---

note:-

mass contreting :-

Ex. in raft foundation
dam
Bridge peir

→ Place concrete in layers 350 - 450mm

- used when concrete subjected to lateral thrust than bond bars
- bond stones are provided to form a key between different layers.

---

note:- under water concreting :-

"using Trernie pipe"

- It uses vertical pipe through which concrete (high slump 150-200mm) is placed by gravity feed below water level.
- bottom end is closed with thin-polythene
- when pipe is completely filled by- concrete, pipe is slightly lifted and given a jerk causing tearing of polythene sheet results into discharge of concrete.
- It should avoid washout of cement due to turbulent water contact with the concrete while it is flowing. this produces a more reliable strength of Product.

⑤ compaction of concrete :-

- process of removal of entrapped air so as to increase density, increase strength & durability of concrete.

v.imp

note :-

voids in harden concrete	if Incomplete compaction →	decrease in compressive strength
5%	30%	
10%	60%	

ways of compaction :-

1- Hand rodding

2- High & shock Pressure

3- centrifugation & spinning (or)

4- mechanical vibration

v.imp

vibrator types :-

or Immersion vibrator

① Internal vibrator / needle vibrator :-

- mostly used
- depth not more than 600mm (D ≯ 600 mm)

② form vibrator – used in congested reinforcement section where needle vibrator cannot used.

Ex. columns, trinc walls, precast unit

③ screed vibrator / surface vibrator :- (depth D < 200 mm)

- is directly placed on the concrete mass for compaction of shallow elements such as road surface, concrete floors
- depth ≯ 200mm

④ vibrating table :- efficient in compacting stiff and harsh concrete mix. required for manufacturing of precast element.

⑤ Plate vibrator :- Compaction of Prefabricated roof elements, door & coindow frame and railway sleeper.

⑥ curing of concrete :-

note: As per IS → 456 :-

- concrete members shall be kept under curing for a minimum period of 7 days for OPC at 90% humidity. and min. 10 days where mineral admixtures are blended cements used.

effect of Improper curing

1- chances of Ingress of chlorides & chemicals ——→ very high

2- cracks formed due to plastic shrinkage

3- rate of carbonation increases.

4- durability decreases due to high permeability.

objective of curing :-

1- to prevent loss of moisture from concrete

(loss due to evaporation or any other reason)

(supply additional moisture to accelerate gain of strength.

2- to ensure hydration process completely,

3- to keep capillary pores saturated

4- to increase durability, impermeability of concrete and reduce the shrinkage

5- It improves wear resistance and weather resistance qualities.

6-

method of curing

Best method

(ponding method)	use
① shading of concrete work or stagnating water	for large concrete surface such as road slab, roof slab
② Gunny bags	for structural concrete
③ sprinkling of water	for vertical surface like column
④ membrance curing	A places of scarcity of water
⑤ Steam curing :-	for precast concrete member

- to increase the rate of strength development.
- put concrete member @ 93°C < low pressure / high pressure
- It reduce shear strength of concrete
- results in increased resistance to sulphate attack and to freezing & Thawing

⑦ finishing :-

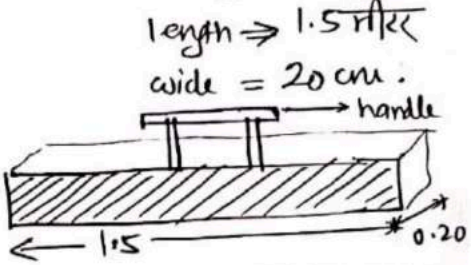
↳ process of levelling & smoothening the top surface of freshly placed concrete to achieve desired appearance.

- done by following →

① screading :- (strikeoff) the excess concrete to bring the top-surface to proper grade.

② floating :- (removing the irregularities) on surface of concrete which are still left after screading.

- floating done by wooden float



③ Trowelling :- (final operation of finishing) tobe done after all excess water has evaporated by steel float (conical shape, gives very smooth finish)

maturity concept in concrete :-

- The strength of concrete not only depend on time but also on temperature during hydration.

$$\text{maturity} = \Sigma(\text{time} \times \text{temp}^\circ\text{C})$$
$$\text{unit} = {}^\circ\text{C-hrs or } {}^\circ\text{C-days}$$

- note:- A datum temp. of (−11°C) is taken for maturity calculation since hydration is started at this temp.

- A sample of concrete cured at 18°C for 28 days is taken as fully matured concrete.

∴ maturity at 28 days

$$= (28 \times 24\ \text{hrs}) \times (18 - (-11))$$
$$= 19488\ ^\circ\text{C-hr.}$$

Gelspace ratio of concrete :-

- ratio of volume of hydrated cement paste to the sum of volume of hydrated cement and of capillary pores.

- $$\text{Gelspace ratio} = \frac{0.657C}{319C + W_0}$$

  C → weight of cement in gram
  W_0 → volume of mixing water in (ml)
  'or'
  → water cement ratio x weight of cement

- $$S = 240x^3$$

  S → strength of concrete
  x → gelspace ratio

Note: Constant 240 :- intrinsic strength of gel in (N/mm^2)

concrete strength Test
or
Test of concrete

- compressive strength test
- Flexural Tensile strength Test
- split tensile strength Test

or

- modulus of rupture Test

① compressive strength Test :-

Test specimen

if agg size > 20mm	if agg size < 20mm
cube = 150mm size or cylinder size l/d = 300mm / 150mm	cube = 100mm

→ fill mix in layers of 50mm, tempt with bar/vibrator

→ test specimen is stored at

- temprature = 27 ± 3°C
- humidity = 90%

for 24 ½ hrs from the time of addition of water to dry ingradients.

→ take sample from mould & immersed in water till testing in machine.

- specimen placed in compression Testing machine CTM & apply load @ 14 N/mm² / minute.

- Is code suggests 28 days cube strength only.

7 days strength = min 2/3rd of 28 days strength.

- avg of 3 specimen is taken { individual variation ≯ 15% of average }

note:- cube strength more than cylinder because contact area of standard cube mould with upper plate in testing-machine is more which results into more confinement thus more strength.

(2) **Flexural Tensile strength Test or modulus of rupture Test** :-

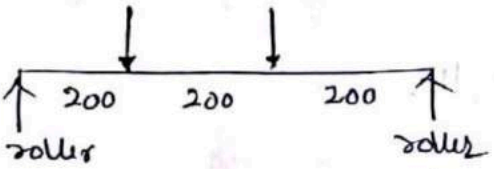
aim → to determine tensile load at which concrete may crack.

- It is indirect test to assess tensile-Strength of concrete.

∵ direct measurement of tensile strength is difficult.

Specimen :- 150×150×700 mm

- Specimen are stored in water at temp. of 27 ± 3°C for 48 hr before testing, testing is done in wet condition



Loading rate = 0.7 MPa/min until failure.

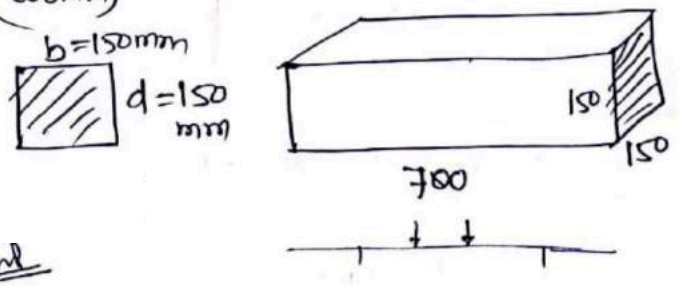
- specimen placed in testing machine on 2-38 mm dia. rollers with c/c distance of 600 mm, then load is applied through 2 similar rollers mounted at the 3rd points of supporting span ie spacing 200mm c/c

modulus of rupture

$a < 170$	$170 < a < 200$
$\frac{Pl}{bd^2}$	$\frac{3Pa}{bd^2}$

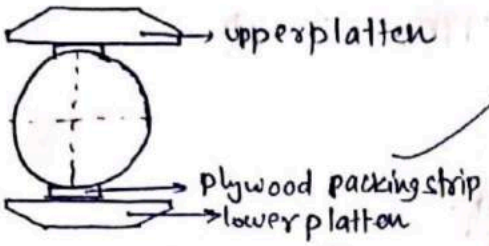
P → max. load applied to specimen

l → length of span on which specimen supported (600mm)

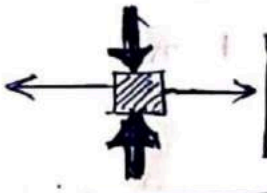


a → distance between line of fracture and nearest support, measured on centre line of tensile side of specimen.

③ Split tensile strength Test :- (Indirect Test)



→ between the Loading platten and cylinder → Packing strips of plywood are placed for uniform distribution of load & to avoid high compression stress near point of application.



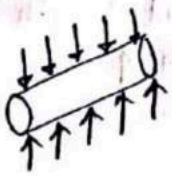
$$f_h = +\frac{2P}{\pi dl}$$ Tensile

$$f_v = -\frac{6P}{\pi dl}$$ compressive

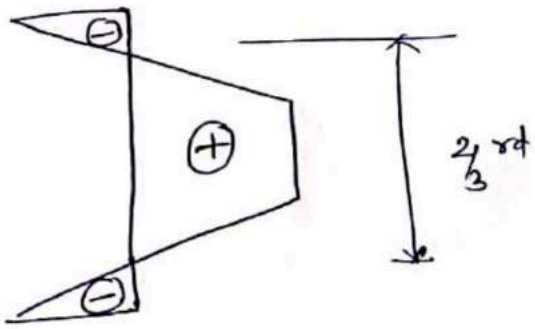
- Specimen $l/d = \frac{300\ mm}{150\ mm}$ placed horizantally b/w the loading surface of CTM (compression Testing machine)

→ 1.2 - 2.4 mpa/min

- compression load applied diametrically and uniformly along the length of cylinder untill failure of cylinder along vertical diameter.



- on application of load, uniform tensile stresses acts over $\frac{2}{3}$rd of loaded diameter



advantage :- (i) gives more uniform result than any other tension test.

(ii) Strength close to actual tensile strength of concrete

(iii) The same mould & compression Testing machine (CTM) (l/d=2) can be used to perform this Test.

limitation :- (i) Test calculates max. tensile stress assuming line load (↓↓↓↓) and uniform distribution of tensile stresses.

{ But concrete has non-linear stress-Strain relationship }

(ii) tensile strength depend on specimen diameters.

factors influence strength of concrete :- (& Quality of Concrete.)

① Aggregate shape :-

- (Flaky aggregate, having elongated aggregates → low strength)
- Rounded aggregate are more workable than angular aggregate.
- Angular Aggregate results into higher strength { ∵ better Interlocking and higher bond characteristic }

② Aggregate grading :-

- well graded aggregates → ~~more~~ voids ↓
  - ∴ less cement paste required ↓
  - ∴ less drying shrinkage ↓
  - ∴ Quality of concrete produced → more durable.

Thus well graded aggregate ↓ high strength of concrete

③ Strength of aggregate :-

- For Preparing high strength concrete we need high strength aggregate, but vice versa is not true.

note:- we must need proper mix design to ensure high strength concrete.

④ specific gravity of aggregate :-

High specific gravity results in strong aggregates hence strong aggregate

⑤ w/c ratio :-

lower the w/c ratio, higher the strength of concrete provided concrete is workable.

(separate discussion → given)

⑥ cement aggregate ratio :-

~~if~~ high then ultimate strength increases provided all other things are constant.

⑦ surface area of aggregate :-

if high → w/c high → ∴ lower strength

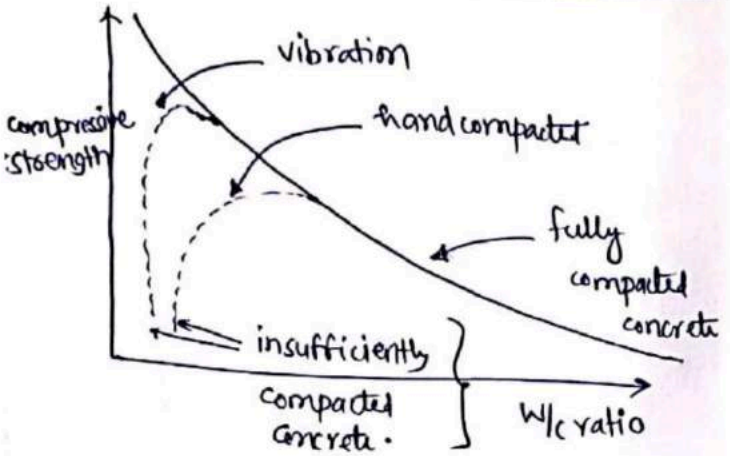
⑧ Surface texture of aggregate :-

if Rough → Higher bond strength thus strength ↑

⑨ compaction :-

Higher compactive efforts → lower voids → higher strength.

effect of w/c ratio on strength of concrete :-



effect of workability on strength of concrete

workability ⟶ means high w/c ratio

- if water cement ratio too high ⟶ it will lead to segregation which is not at all desirable.

Type of formwork	min. period before removal of formwork
Vertical formwork to column, walls, beams	16 – 24 hrs
Soffit formwork to slabs (Props to be refixed immediately after removal of formwork	3 days
Soffit formwork to beams	7 days
Props to slab → span upto 4.5m	7 day
→ >4.5m	14 day
Props to beam & arch → span ≤ 6m	14 days
span > 6m	21 days.

note:- • above specifications are valid for OPC & where ambient temp. don't fall below 15°C and adequate curing is done.

- for other cement & lower temp., the stripping/removal time recommended above may be suitably modified/changed

characteristic strength of concrete is measured at 28 days.

Age	strength
1 day	16 %
3 day	40 %
7 day	65 % ≈ 2/3
14 day	90 %
28 day	99 %

Physical Properties of concrete

- Poisson ratio
- creep
- modulus of elasticity
- Stress strain curve.

① poisson ratio :

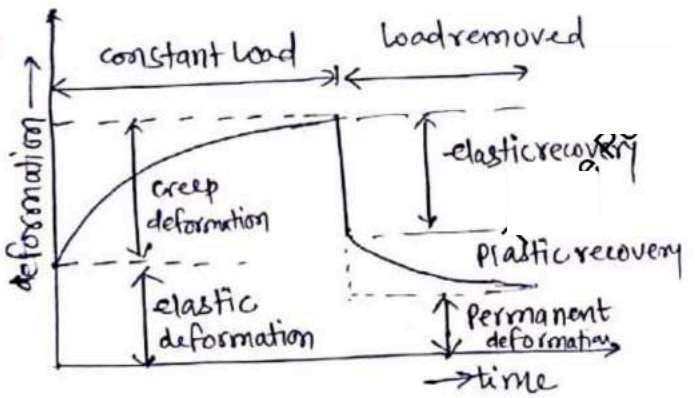
$$\mu = \frac{-\text{lateral strain}}{\text{longitudinal strain}}$$

range = 0.10 – 0.30
avg value = 0.15

$\mu = 0.1$ ⟶ High strength concrete

$\mu = 0.2$ ⟶ weak mix.

② creep :



creep → plastic flow/time yield

↳ continued deformation with time under a constant load.

rate of creep decrease with time at 5 years, creep strains are taken as terminal value.

Age	Creep coefficient ϕ
7 day	2.2
28 days	1.6
1 year	1.1

Creep increases when ⟶

(I) loading occures at early age
(II) loading is sustained over a long period
(III) size/ thickness of membd ⟶ small
(IV) Cement content is high
(V) w/c ratio is high
(VI) Aggregate content is low.
(VII) Air entrainment is high
(VIII) Relative humidity is low
(IX) temp. is high

(3)

① modulus of elasticity of plain cement concrete

(1) concrete is heterogeneous, multiphase material, whose rheological behaviour is influenced by elastic properties and morphology of gel materials.

(2) As a result, the stress-strain-curve does not exactly Hooke's law.

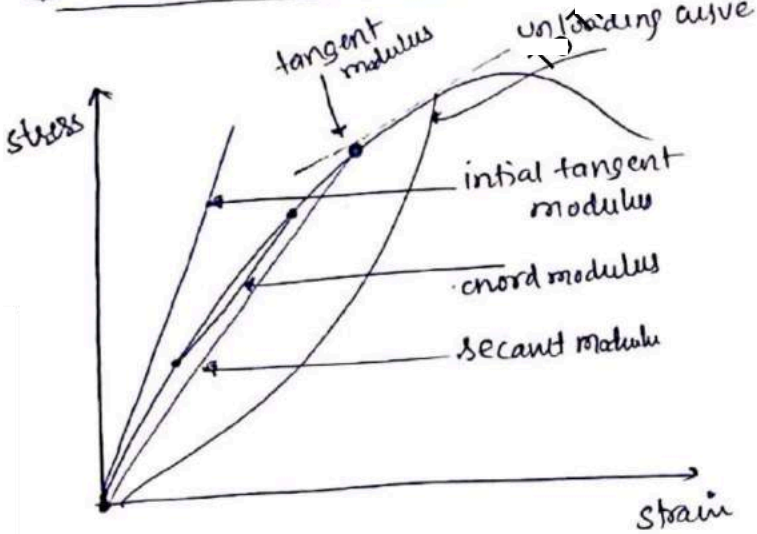
• But since this curve for concrete is not straight at any point, the modulus of elasticity is find out with reference to tangent drawn to curve at the origin. this is called initial tangent modulus.

But it gives satisfactory result at low stress values only.

tangent modulus :- A tangent drawn from any other point on stress-strain curve.

• But it gives satisfactory result in the vicinity of point considered.

② Static moduli of elasticity :-



Secant modulus :- most commonly used

↳ given by slope of line drawn connecting a specified point on curve to origin of curve.

• The value of secant modulus decreases with increase in stress at which it is found should always be stated.

chord modulus :- find out by chord drawn b/w 2 specified point on stress strain curve

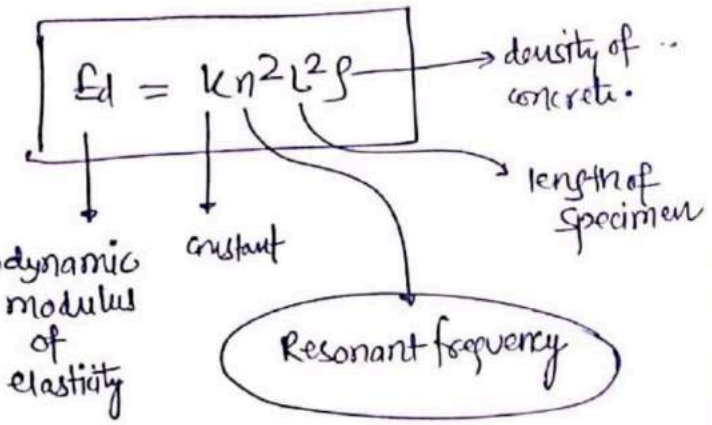
• It is defined as slope of stress-strain curve for concrete under uniaxial tension / compression loading.

↳ Static modulus of elasticity

note:- Static modulus of elasticity does not truely represent elastic behaviour of concrete due to creep. It will get affected more seriously at higher stresses.

③ Dynamic modulus of elasticity :-

- It can be find out by subjecting the concrete member to longitudinal vibration at their natural frequency.



④ factors affecting modulus of elasticity

1- effect of moisture condition
2- effect of Aggregate properties
3- effect of cement matrix.
4- effat of transition zone

workability of concrete

① workability is referred to as the ease with which a concrete can be transported, placed, and consolidated without excessive bleeding or segregation.

② workability defined as internal work done in overcoming the frictional forces between concrete ingradients for full compaction so water functions as a lubricant so that concrete can be compacted upto maximum possible extent.

factors affecting workability :-

factor	effect on workability
water content (direct relation)	• as water content increases, fluidity of mix increases so workability increases.
Aggregate/cement relation (inverse relation)	• Higher the ratio, leaner the concrete, lower the workability. • lean concrete means concrete having less paste available for lubrication of per unit surface area of aggregates.
aggregate size (direct relation)	workability ↑ ∝ agg size↑ • Big size aggregate, surface area to be wetted is less, paste required for lubricating the surface will be less
Shape of Aggregate	• Angular & Flaky aggregate → less workable. • rounded cubical shape aggregates have less surface area, so less amount of paste is required for lubrication. so they are more workable
Surface texture	• smoother the surface, higher workability.
grading of aggregates (direct relation)	• well aggregate are more workable • such mix will have least voids where excess cement paste will be available as lubricants
Admixtures	Plasticizer increases workability

workability Test order :-

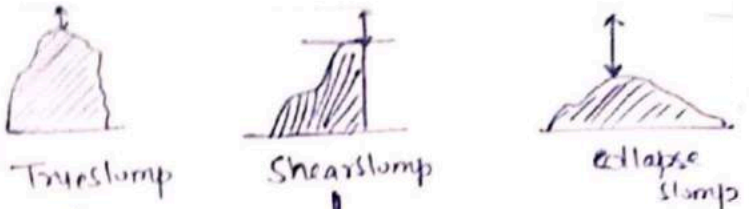
Vee-Bee < CF Test < slump test < flow Test

- Vee-Bee → very low dry.
- flow Test → for high & very high workability

workability Test

① Slump Test :- (In situ workability Test)

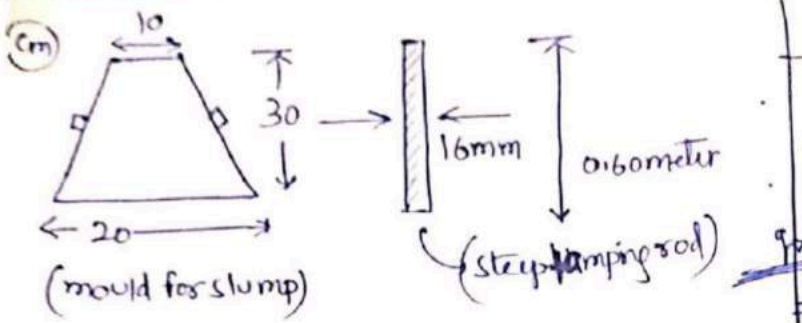
Info:
- not for very wet concrete
- not for very dry concrete



True slump → Even slump

Shear slump → when one half concrete slided down.

Collapse slump → incase of wet concrete



workability (Slump (mm)) Collapse > Shear > True slump

Note:- Shear slump indicates a non cohesive concrete & may lead to segregation.

- Put mould over smooth, horizontal, rigid and non absorbent surface
- fill in 4 layers
- each layer tamped 25 times by rod.
- after top layer has been rodded, the concrete is struck off level with a trowel & tamping rod.
- The mould is removed immediately by lifting it vertically:

The concrete will Then Subside and this Subsidence is refer as Slump (in mm)

↳ The difference b/w the height of mould and highest point of subsided concrete (in mm) ⟶ taken as slump.

Degree of workability	Consistency	Slump (mm)	CF	VB (sec)	Uses
Extreme low	moist earth	0	0.65 - 0.78	>20	Precast paving slab
very low	very dry	0-25	0.7 - 0.8	12-20	roads vibrated by Power operated machine
low	dry	25-50	0.80 0.85	6-12	• mass concreting • light reinforced sections • roads (hand vibrator)
medium	Plastic	50-100	0.85 0.95	3-6	• flat slab • moderately reinforce section • RCC section (manual vibrator)
High	semi-fluid	100-150	0.95-1	0-3	RCC with congested reinforcement (cannot be vibrated)
very high	fluid	>150	>0.95	—	Flow table Test is most suited.

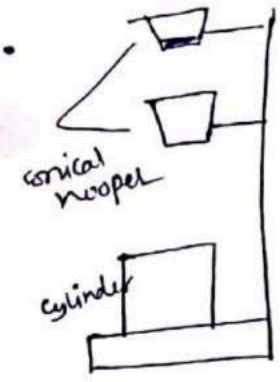
Types of concrete	Slump (mm)
Concrete to be vibrated	10 - 25
Road construction	20 - 40
mass concreting	25 - 50
Parapets, piers, slab, beam, column, wall	40 - 50
Concrete for canal lining	70 - 80
normal RCC work	50 - 120

(2) Compacting factor Test :-

(for low to medium workability)
CF = 0.80 - 0.90

note:- concrete of very low workability (CF < 0.7) not suitable because thus concrete can not be fully compacted for comparison in the manner described in test.

- In this test agg size ≯ 40mm



- weight of concrete (falling freely) in the cylinder is determined to the nearest 10gm is known as wt of partially compacted concrete.

- cylinder is refilled with concrete from the same sample in layers of 50mm deep, each layer being heavily rammed or preferably vibrated so as to obtain full compaction

- The mass of concrete in the cylinder should be measured if it is known as mass of fully compacted concrete

$$\text{compacting factor} = \frac{\text{mass of partially compacted concrete}}{\text{mass of fully compacted concrete}}$$

③ Vee-Bee consistometer Test → (for dry mix)

- consistency expressed in [VB degree] → (recorded in time second)
- This Test determined (time) required for transforming (by vibration), a concrete specimen in the shape of conical frustum into cylinder.

④ Flow Test :- (high & very high Workability)

↳ including flowing concrete which could exhibit (collapse slump)

non-destructive test of concrete (NDT)

(1) • It is wide group of analysis technique used to evaluate property of concrete without damage.

(2) The strength of concrete is therefore inferred from some-other properties values of which for a good concrete sample are-already known.

(3) So, Instead of absolute values an estimate of its strength durability and elastic parameter are obtained.

(4) Though these tests are easy to perform but their analysis requires special knowledge.

need of NDT :-

(A) In new structure →

(I) quality controll of construction

(II) monitoring of strength development in relation to formwork removal, Curing, prestressing, load application.

(III) uncertainties concerning the level of workmanship involved in construction operation affecting harden properties of insitu concrete.

(IV) non complainee of material supplied interms of works specimen test results or other specified requirem

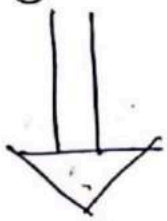
---

(B) In existing structure :-

(I) due to external & internal chemical attack, fire explosion and other environmental effect

→ By NDT, we can find deterioration of concrete.

(II) assessment of load carrying capacity of existing structure



for changes of its uses
or
for change of ownership

Merits / advantages of NDT :-

(i) don't cause any damage to structure / specimen & no wastage of material hence saves lot of time and money

(ii) easy to perform (relatively)

(iii) measurement can be done on concrete at site (insitu) and hence representative samples are not required.

(iv) NDT usefull to study variation in quality of concrete with time and external influence.

(v) we can perform test on existing concrete structure hence can devise repair plan.

(vi) These test can be categorised into those that assess the strength of concrete insitu and those that determine other charactersti of concrete

like voids
flows
cracks
deterioration

Different methods of NDT

(i) Surface hardness test :-

These are of indentation type, include williams testing pistol and impact hammers, are used only for estimation of concrete strength.

(ii) Rebound hammer Test :-

- measures elastic rebound of concrete and is primarily used for estimation of concrete strength and for comparative investigation

(iii) Penetration and pull out test :-

- measure penetration and pull out resistance of concrete and are used for strength estimation, they can also be used for comparative studies

(iv) dynamic / vibration / Ultrasonic pulse velocity test

- used to evaluate durability and uniformity of concrete and to estimate its strength and elastic properties.

(v) radioactive and nuclear methods :-

- uses x ray and gamma ray penetration test for measurement of density and thickness of concrete. Also neutron scattering and neutron activation methods are used for moisture and cement content determination.

(vi) magnetic & electrical method

- magnetic method → determine cover to bars
- electrical method → to get moisture content & thickness of concrete. (microwave absorption technique)

(vii) Acoustic emission technique : to study the initiation and growth of cracks in concrete.

(viii)

14/7/2020