BUILDING MATERIALS

GATE (1 MARK)

-- Kp Sir

⇒ **Building Material** (ORIGIN)

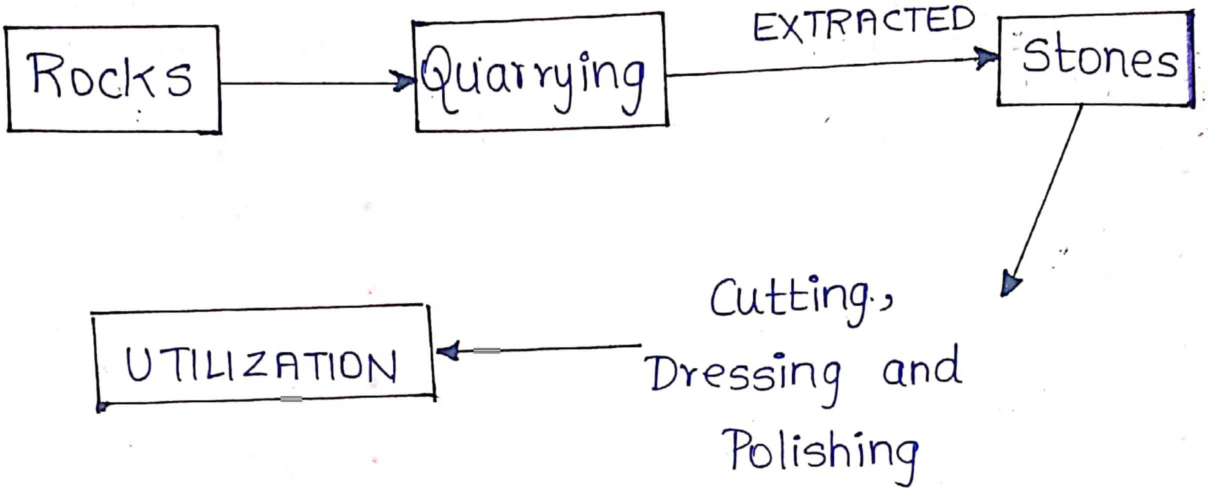
- Natural
  - Stones
  - Timber
  - Clay
  - Mud
  - Sand
- Man-Made (ARTIFICIAL)
  - Cement
  - Bricks
  - Steel
  - Glass
  - Lime

⇒ **Building Materials** (FUNCTIONS)

- Primary
  - Stones
  - Bricks
  - Timber (Wood)
- Mortars
  - Cement
  - Lime
  - Surkhi
  - Mud
  - (Binding Material)
- Aggregates
  - CA (Gravel)
  - FA (Sand)
- Concreting Material
  - Cement
  - Aggregate
  - Water
- Miscellaneous
  - Steel
  - Iron
  - Aluminium

1. BUILDING STONES

- → Naturally Available
- → Durability > 50 years
- → Construction possible without Joints.



→ **DRESSING**

The process of converting freshly quarried stone of :

Large size, Rough and Irregular shape

↓

Regular size, Smooth and Regular shape.

CLASSIFICATION OF STONES

GEOLOGICAL CLASSIFICATION

(Based on Parent Rock)

(i) **IGNEOUS ROCKS**:

Rocks formed by Cooling of Magma

- aka Cruptive / unstratified
- TYPES:
  - BELOW GROUND
    - (a) Plutunic Rock : DEEPER DEPTHS
      - Ex: Granite
    - (b) Hypabyssal Rock : SHLLOW DEPTHS
      - Ex: Dolerite
  - (c) VOLCANIC Rock : POURING OF MAGMA ON SURFACE
    - Ex: Basalt

PHYSICAL CLASSIFICATION

(i) **STRATIFIED Rocks** :

Layered and shows Plane of cleavage

Ex: sand stones and lime stones.

ii) **UN-STRATIFIED Rocks** :

Not Layered and Crystalline

Ex: Granite, Ballast, Trap

(iii) **FOLIATED ROCKS** :

Tendency to Break in a Specific direction

Ex: slate

ENGG / SCIENTIFIC CLASSIFICATION

(Based on chemical nature)

(i) **SILICIOUS Rocks**

Silica (SiO_2)

Ex: Granite, Quartzite, Laterite

(ii) **ARRGILLACEOUS Rocks**

Alumina → $\boxed{Al_2O_3}$

Dense, Soft and Compact

Ex: slate, Laterite

- GEOLOGICAL CLASSIFICATION (contd)

(ii) SEDIMENTARY ROCKS :

Igenous rocks after weathering and settling

Ex: Gypsum , Gravel,
Sandstone, Lime stone

(iii) METAMORPHIC ROCKS :

change in characteristics of i) and ii).

Ex: Marble , Gniess,
slate

ENGG. CLASSIFICATION

iii) CALCAREOUS ROCKS

Consits $\boxed{CaCo_3}$

- imparts durability

Ex : Lime stone,
Marble.

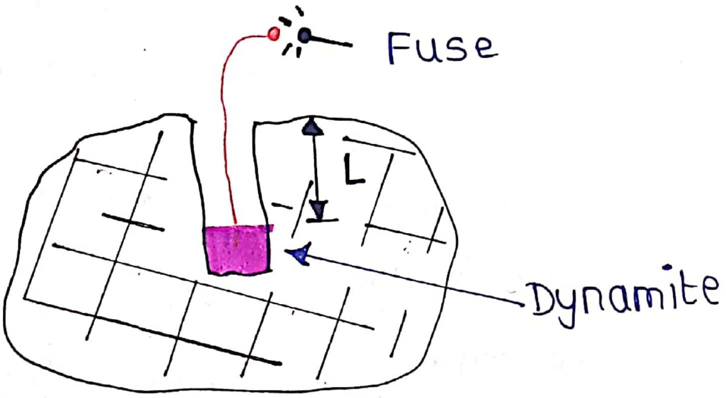
– QUARRYING

→ Extraction of stones from Quarry (Rocks)

- QUARRING WITH HAND TOOLS
  1. Digging
  2. Heating
  3. Wedging
- QUARRYING BY CHANELLING MACHINE
- LARGE SCALE QUARRYING
  - By Blasting
    - Using Dynamite
    - Gun Powder
    - Gelatin sticks

* Quantity of Gun powder or Dynamite Req (grams) $= \dfrac{L^2}{0.008}$

(L → Shortest Distance of Explosive from Rock face)



(ROCK STRATA)

2. BRICKS

- Artificially made Building materials with Naturally available Clay.

↖ Brick Earth.

- Composition of Brick Earth

** ***

[IS 2117-1975]

INGREDIENT	%	IMPARTS (Adv.)	DISADVANTAGES
1. Silica	50-60%	Give shape and Durability * * and Prevents cracking and shrinkage	• EXCESS : Destroy Cohesion b/w Particle and Bricks Brittle (weak in Burning)
2. Alumina (Al_2O_3)	20-30%	Gives plasticity	• EXCESS : Cracks, Shrinkage.
3 Lime ($CaCO_3$)	Not Exceeding 5%	Prevents shrinkage of Raw Bricks.	• EXCESS : → Lost the shape → split into pieces

4. Oxides of Iron	5-6%	- Gives Red Colour to Bricks. - Helps to fuse with sand. - Improves (↑) durability and Permeability	• DEFICT: Bricks becomes yellowish. • EXCESS: Dark blue or black bricks.
5. Magenesia	Trace Elements (1%)	- Decrease shrinkage - Yellowish Tint	• EXCESS: Decay of Bricks.

→ Bricks are made of → Burnt clay
(or)
→ Mixture of sand and Lime.

→ Standard size : 19 x 9 x 9 cm [WITHOUT MORTAR]

→ Nominal size : 20 x 10 x 10 cm [WITH MORTAR]

→ Wt. of 1 m^3 of Brick Earth ⟹ 1800 kg

→ Avg. wt of 1 Brick ⟹ 3 - 3.5 kg

- Harmful Ingrediants of Brick Earth :

1, ALKALI : Causes Efflourescence → White powder deposits on Brick surface

→ Unsuitable for Construction.

2. IRON PYRITES: Decolorization & Disintegration

3. PEBBLES & VEGETABLE MATTER: Bricks become more porous ⇒ Water Absorbance ↑

⇒ strength ↓

- Additives [ADDITIONAL INGREDIANTS]

1. Fly Ash
2. Sandy Loam
3. Ballast stone Dust
4. Rise Husk Ash.

→ Increase STRENGTH and DURABILITY

– MANUFACTURING OF BRICKS

PREPARATION OF BRICK EARTH

1. Unsoiling: Remove 20cm Top soil
2. Digging: Take clay from soil strata (60-120cm)
3. cleaning: Removal of unwanted from clay
4. Weathering – (15 days)
5. Blending – (mixing)
6. Tampering (Add req water and mix using Pug mill)

MOULDING

- Hand Moulding
  - GROUND
  - TABLE
- Machine Moulding
  - PLASTIC METHOD
  - DRY - PRESS METHOD

DRYING

- Natural
  - Sun - light
  - Stacking Method
- Artificial
  - Tunnel drying
  - Hot Floor Dryer

BURNING

- (Temporary) clamp Burning
- (Permanent) kiln Burning

⇒ STAGES:

i) Dehydration

(ii) oxidation

(iii) Vitrification

[– DRYING: (Removal of Moisture) @ T ≤120°c

– BURNING: (make Brick Hard and Impart strength) @ T=600-1200°c]

- The process of grinding clay with water and making it plastic is called <u>Pugging</u>.

* Size of Bricks :

- CONVENTIONAL (or) TRADITIONAL BRICKS : $23 \times 11{\cdot}4 \times 7{\cdot}6$ cm
- STANDARD BRICKS : $19 \times 9 \times 9$ cm.

- Bricks carry $\boxed{\text{Frog}}$ → $10\text{ cm} \times 4\text{cm} \times 1\text{cm}$ for Brick of $19 \times 9 \times 9$ cm.

(*) FORMULAS :

1. $$\text{No. of Bricks } (N) = \frac{\text{Volume of Brick Masonary}}{20 \times 10 \times 10 \times 10^{-6}}$$ ↗ m^3

2. $$\text{Volume of Bricks} = N \times 19 \times 9 \times 9 \times 10^{-6}$$

3. $$\text{Volume of Mortar} = \text{Vol. of Brick Masonary} - \text{Vol. of Bricks}$$

4. $$\text{Volume of set Mortar} = V_{\text{mortar}} + \text{Additional \% of } V_m \text{ for Lost b/w}^n \text{ Joint } (0-20\%)$$

(Wastage | compaction)

Eg: $V_m = 1\cdot5 m^3$, $V_{set} = 1\cdot2 \times 1\cdot5 = 1\cdot8 \ m^3$

↑ Calculated ↑ Actually Taken – Volume of set mortar.

5, Actual Volume of Bricks = $V_{\text{Brick Masonary}} - V_{\text{set mortar}}$.

6, No·of Bricks (actual No· of Bricks). = $\dfrac{\text{Act· Volume of Bricks}}{19 \times 9 \times 9 \times 10^{-6}}$

Q. Modular bricks of size 20×10×10 cm are used for masonary work having 25% of Volume of Mortar Lies b/wⁿ Joints. Find no' of Bricks required to construct a brick Masonary wall of 5 m³. ?

Soln 1, No· of Bricks = $\dfrac{5}{20 \times 10 \times 10 \times 10^{-6}} = 2500$

2, $V_B = 19 \times 9 \times 9 \times 10^{-6} \times 2500 = 3\cdot84 \ m^3$

3, $V_m = 5 - 3\cdot8475 = 1\cdot1525 \ m^3$

$\Rightarrow V_{sm} = 1\cdot25 \times 1\cdot1525 = 1\cdot44 m^3$
(25%)

$\therefore V_{Bricks} = 5 - 1\cdot44 = 3\cdot56 m^3$

$N = \dfrac{3\cdot56}{19 \times 9 \times 9 \times 10^{-6}}$

$\Rightarrow \boxed{N = 2313}$

(Ans·)

Q, Determine Number of Traditional bricks required for making 10^3 of Masonary Work?

Solution $$N = \frac{10^3}{23 \times 11 \cdot 3 \times 7 \cdot 6 \times 10^{-6}} = 5018$$ (GATE-94)

$$\boxed{N = 5018}$$

*
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3. CEMENT (Means to Bind)

(BINDING) (BONDING)

A building material with cohesive and adhesive (ATTACHMENT) properties by crushing of clinkers which are formed due to burning of desired properties of calcarious or argillaceous raw materials at high temperature in a rotary Klin is called as CEMENT

→ RAW MATERIALS,

CALCAREOUS

(From $CaCO_3$)

↓

Lime stone, Chalk, Kankar, Cement Rocks, Alkali Waste

ARGILLACEOUS

(From clay & Al Compounds)

↓

Clay, Ash

→ Cement Invented by ⟶ $\boxed{\text{JOSEPH ASPHEDIN}}$

(OPC- Oridinary Portland Cement)

* Cement + water : Cement Paste → Binding Material

* Cement + sand (FA) + Gravel (CA) + water → $\boxed{\text{Concrete}}$

* Cement + sand + water → Mortar.

* Ingrediants of cement → Lime, silica, Alumina
  [PRIMARY INGREDIANTS]

[Al_2O_3 → Alumina, Al → Aluminium]

Chemical Element ↗ Al

* $CaCO_3 \xrightarrow[\text{kiln}]{900^\circ c} CaO + CO_2 \uparrow$

$CaO + H_2O \rightarrow Ca(OH)_2$

(Volume ↑)

[SLAKING OF LIME]

Scanned by CamScanner

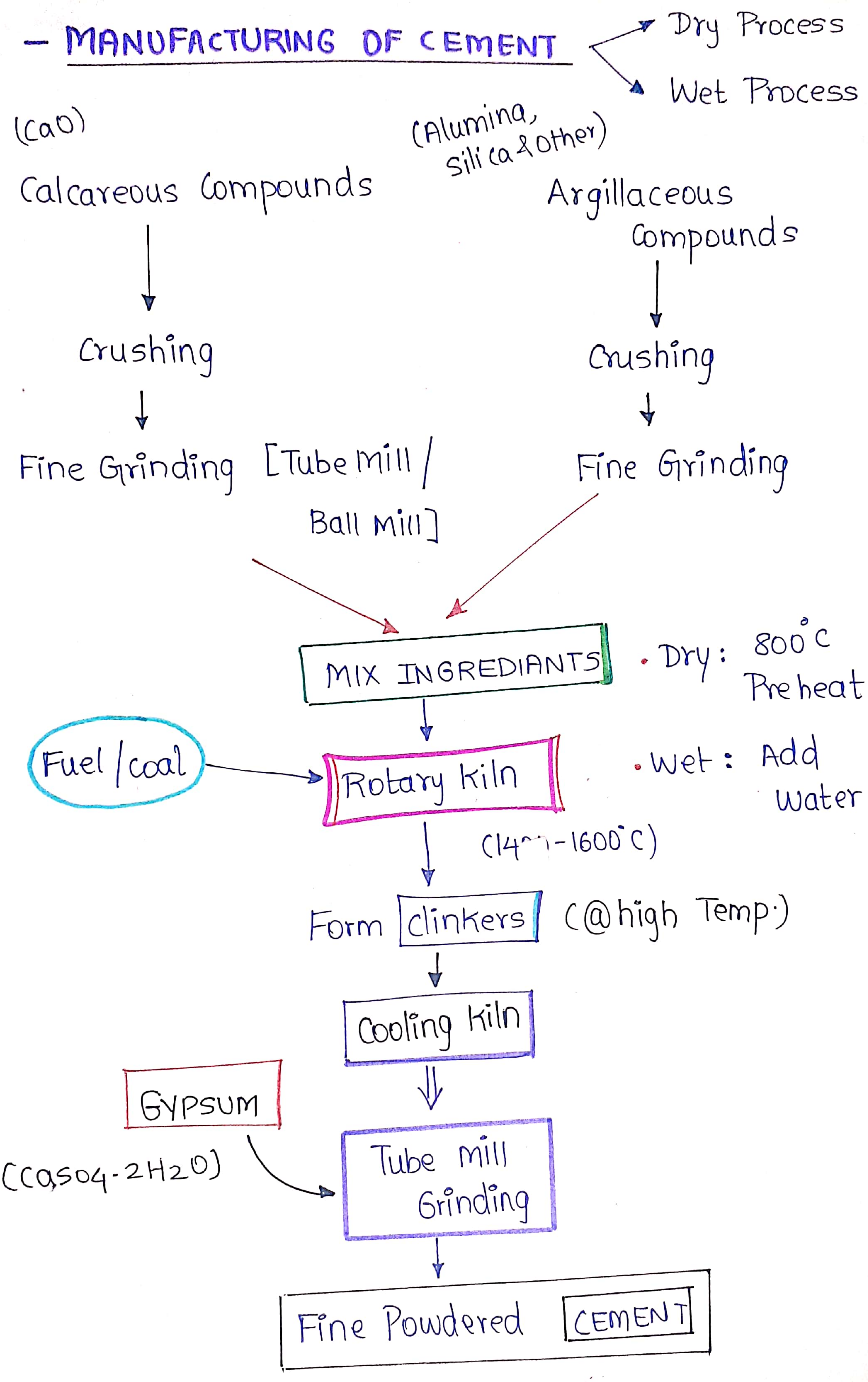
most *	COMPONENT	%	FUNCTION	EXCESS	DEFECIT
1.	Lime [CaO]	62-65 %	Strength Soundness (strong and Durable	Unsound, Expansion takes place (Slaking of Lime)	Reduces strength and setting Time
2.	Silica $[SiO_2]$	18-25%	strength	Increases strength, but slowers the setting Time	Reduces strength.
3.	Alumina $[Al_2O_3]$	5-9 %	*** Quick (Flash) setting	Lower strength Reduces setting Time	More Setting Time

* To control Quick setting due to Alumina ⟶ **GYPSUM** (Retarder)

most * COMPONENT	%	FUNCTION	EXCESS	DEFECIT
4. Ironoxide (Fe_2O_3)	5%	Imparts – Colour [Greenish Grey] * *Catalyst	Unsound, Strength ↓	Slow fusion of ingrediants ∴ Fuel consumption ↑, Cost ↑
5. Magensia (mgo) [unwanted] (Available : 0·1–4%)	0%	- colour formation - Imparts Hardness	→ Most Dangerous → Cause Cracks after setting, Weakens Cement	
6. Gypsum ($CaSO_4 \cdot 2H_2O$)	1–3%	- Regulate IST (Initial setting Time) - Causes soundness	Unsound	

most *	COMPONENT	%	FUNCTION	EXCESS	DEFECIT
7.	Alkali (Na_2O, K_2O)	0.2-1%.	- (No Function)	1. Porous ↑ : Water Abs. ↑ 2. Alkali-Agg. Reaction : → Expansion → Deterioration 3. Efflourescence.	-
8.	SO_3 (Sulphur-tri-oxide)	1-3%.	Soundness	Unsoundness.	

– MANUFACTURING OF CEMENT

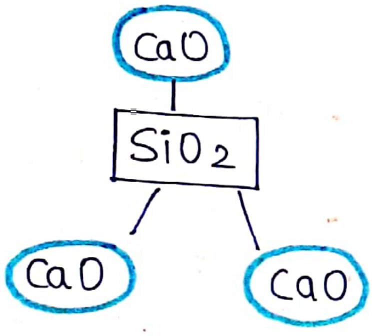


- BOGUES COMPOUNDS

The chemical compounds formed as a result of chemical interaction of ingrediants of cement [Grinding, Drying, Burning & Fuse together], When it is mixed with water are Called BOGUES COMPOUNDS, but not formed simultanuously

1. TRICALCIUM SILICATE

$[3\,CaO\,SiO_2]$ - C_3S



[CaO → Calcium $\boxed{C}$

SiO_2 → Silicate $\boxed{S}$

Al_2O_3 → Aluminate $\boxed{A}$]

- Generally : 45-65%
- In OPC : 40-50%
- Formed : within a Week (or) 2 Weeks after addition of water.
- First Bouge's compound. ∴ Responsible for "EARLY STRENGTH"
- AKA Allite.

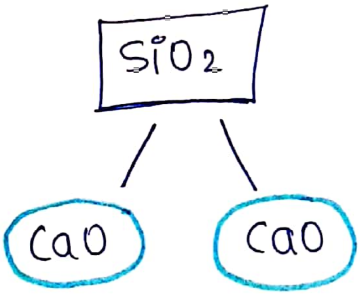
* HEAT OF HYDRATION : 500 Joules/gram. **

* FUNCTION : 1, Best Cementing Property ** among all

2, Contribute Initial & Final strength

2, DICALCIUM SILICATE [C_2S] – Belite

[$2CaO \cdot SiO_2$]



- In general : 15 - 35 %.
- For opc : 25 - 30 %.
- Undergo hydration after 1 year or more of addition of water.

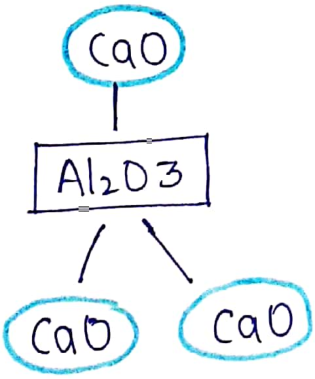
* FUNCTION : 1, Ultimate Progr. strength

2, Resistance → chemical attack

→ Acid Attack

- Heat of Hydration : 265 Joules/gram.

3. TRICALCIUM ALUMINATE [C_3A] – Celite



[$3 CaO. Al_2O_3$]

- undergoes Hydration with in 24 hours of water addition.
- HIGHEST HEAT OF HYDRATION : 865 Joules/gram

* In general : 4-4%

and 8-12% in OPC

* <u>FUNCTIONS</u> : Flash setting, No strength contribution.

- Weakens Resistance against sulphate attack.

4. TETRA CALCIUM ALUMINO FERRATE - Fellite

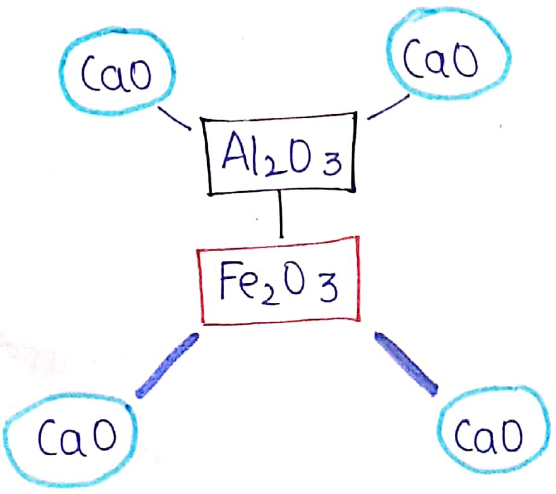
[C4AF]

[$4CaO \cdot Al_2O_3 \cdot Fe_2O_3$]

- In General : 10-18 %
- In opc : 6-10 %

→ Undergoes Hydration within 24 hours of water addition.

- Flash setting, Poorest cementing value.
- Heat of Hydration : 420 Joules/gram.



- DEGREE OF REACTION [RATE OF HYDRATION] :

$$C_3S + H_2O \xrightarrow{\text{Fast}} C\text{-}S\text{-}H + 3\,Ca(OH)_2$$

$$C_2S + H_2O \xrightarrow{\text{slow}} C\text{-}S\text{-}H + Ca(OH)_2$$

C - S - H

Calcium - silicate - Hydrate → TOBERMORITE GEL

CaO SiO_2 H_2O

(Natural mineral)

* $\boxed{C_4AF > C_3A > C_3S > C_2S}$

(order of RATE OF REACTION)

* **Order of Heat of Hydration** ***

$\boxed{C_3A > C_3S > C_4AF > C_2S}$

* **Order of Binding Property and strength**

$\boxed{C_3S > C_2S > C_3A > C_4AF}$

Total Water Requirement for Hydration $\Rightarrow W = aP + bQ + c.R + d.s$

Where, a, b, c, d : Propotion of Bouges Compounds

P, Q, R, S : Water Requirements for Respective $\boxed{BC}$

Water in Cement –
- → COMBINED WATER → Reacts with $\boxed{BC}$ ∼→ 23%
- → GEL WATER → adsorbed on cement Grain ∼→ 15%
- → CAPPILARY WATER → in b/w^n cement coarse/voids of cement Grain. ∼→ 12%

(23% + 15%) — 38

- Water Req̄ to be added ∼→ 38%.

→ Specific Gravity of cement → 3.15 g/cc (Cement silos)

→ Mass Density of Cement → 1.5 g/cc [1440 kg/m3]

→ ∴ Wt. of 1 Cement Bag → 50 Kg

Volume of 1 Cement Bag → 34.7L ≃ $0.034\ m^3$

$$\therefore \text{Density} = \frac{50}{0.034} = 1440\ Kg/m^3$$

Q A 28-S type mixer has a Capacity of 20 m^3 with working Effeciency of 80 %. 1 m^3 of concrete require 5.5 bags of cement. Find vol. of concrete to be mixed per bat$\overset{c}{}$h in order to avoid fractioned use of cement bag.

Solution : Working capacity = 80 % of 20 = 16 m^3

* 1 m^3 ⟶ 5.5 bags

16 m^3 ⟶ ?

16 × 5.5 = 88 bags

Concrete vol : $\boxed{16\,m^3}$

⇒ TESTS OF CEMENT **

IS 4031

- Field Tests
- Lab Tests

* Laboratory Tests

1. Fineness Test : (a) Sieve Test [90μ] , (b) Blain's Permeability Test
   (c) sedimentation method.

***
2. Specific Gravity Test : Le-chatlier Flask

***
3. Consistency Test : Vicat's Appratus with Plunger

***
4. Setting Time Test :
   [OPC]
   - → IST (30 min)
   - → FST (600min or 10hr)
   - → IST : Vicats with Needle
   - → FST : Vicats with Needle + Angular collar.

5. Strength Test :
   - → Compressive str̄ Test : CTM/UTM
   - → Tensile str̄ Test : Briquette Testing machine.

***6. Soundness Test :

IS 3555

(a) Due to Lime → Lechatlier's Appratus

(b) Due to Magnesia → Autoclave Test.

(c) Due to sulphate → chemical Analysis.

7. Heat of Hydration : Adiabatic - calorimeter

* CONSISTENCY TEST :

Find out min. amount of water to be mixed with cement to make Uniform, Homogenous, Workable cement Paste

→ Corresponding Wc (%) : 30-40% (35%)

* SETTING TIME TEST :

To check the Extent of Deterioration of cement quality during storage.

- **INITIAL SETTING TIME :** Time interval b/w addition of water to cement till it starts Losing Plasticity

  (Attains stiffness)

→ For IST : Cement paste : 500 g Cement + 0·85 $\boxed{P\%}$ of water

- FINAL SETTING TIME :

Time interval b/wⁿ addition of water to Complete Lose of plasticity (Hydration)

3. FINENESS TEST

To check ability of Grinding of cement ↓ Cement Grains FINER

→ For STRENGTH TEST :

- * P·% of water = $[\frac{P}{4} + 3]\%$ of Wt of cement
- * Cement : sand ⇒ $\boxed{1 : 3}$
- * Mould Used : 7·06 × 7·06 × 7·06 cm [Compressive strength]
- * Compressive Load : 35 N/mm²/min

- Requirement :

(a) $$\frac{\text{Strength @ 3 days}}{\text{Strength @ 28 days}} \nless \frac{1}{2} \; [\nless 50\%]$$

(b) $$\frac{\text{Strength @ 7 days}}{\text{Strength @ 28 days}} \nless \frac{2}{3} \; [\nless 67\% \; (66.66\%)]$$

AGE	COMPRESSIVE STRENGTH (N/mm^2)		
	OPC-33	OPC-43	OPC-53
1. 3 Days	16	23	27
2. 7 Days	22	33	37
3. 28 Days	$\boxed{33}$	$\boxed{43}$	$\boxed{53}$

- For Tensile Strength Test : Water Req → $\left[\frac{P}{5} + 2.5\right]$ % of Cement

- For Le-Chatlier Test : $\underbrace{(0.78 \times P)}_{\text{Percentage of water from consistency Test.}}$ %

4. AGGREGATE → Give Volume to Concrete and make it Economical.

BASED ON SIZE

1. FINE AGGREGATE

- As per IS 383 : Size < 4.75 mm

Ex: Sand, Ash, Surkhi, Crushed stone

→ Filler Material
→ Help for Workability (due to ↑ High specific surface Area.

BASED ON OCCURANCE (origin)

1. NATURAL :

From Igneous, Sedimentary and Metamorphic Rocks

Ex: Sand, Gravel, Ballast.

2. ARTIFICIAL :

Surkhi, GGBFS Ash
(Ground Granulated Blast Furnace Slag)

SURFACE TEXTURE

Ⓐ Rough

CA → Crushed Granite

Ⓑ Smooth

FA → River sand.

BASED ON SHAPE

(I) REGULAR

(a) Rounded

River sand

(b) Angular

Crushed Granite

(II) IRREGULAR

Flaky and Elongated.

2. COURSE AGGREGATE

Retained on 4·75mm

∴ Size > 4·75 mm

Ex: Gravel, Ballast, stones.

→ Contributes $\boxed{\text{strength}}$

* ANGULAR NUMBER : Measurement of Roundness / Angularity

↓

Volume of voids in a sample.

AN	0	1	2	3	4 -------- 11
% of voids	33 %	34%	35%	36%	37% 44 %

Q. The wt of CA having $G = 2.65$ filled into a cylinder of Vol. of $0.01 m^3$ is 17500g . What is AN ?

Solution

$$G = \frac{\rho_s}{\rho_w} = \frac{M_s}{V_s \cdot \rho_w}$$

$$\Rightarrow 2.65 = \frac{17.5}{V_s \cdot \times 1000}$$

$$\Rightarrow V_s = 6.66 \times 10^{-3} \ m^3$$

$$V_v = V - V_s \qquad \Rightarrow V_v = 0.01 - 6.66 \times 10^{-3}$$

↑ Total Volume

$$V_v = 3.39 \times 10^{-3} \ m^3$$

$$\text{Now, } \underset{(\text{voids})}{\% V} = \frac{3.39 \times 10^{-3}}{0.01} \times 100 = 34\% \rightsquigarrow 1$$

$$\boxed{AN : 1}$$

Q. An Aggregate mixture contains 40% Fine Ag. and 60% CA with Fineness Modulus of 2.5 and 7.5 respectively. Find Mix Fineness Modulus ?

Solution

$$FM_{(mix)} = \frac{(2.5 \times 40) + (7.5 \times 60)}{100}$$

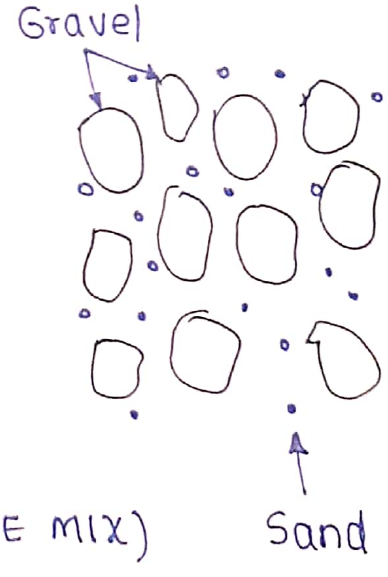
↖ Weighted Avg. Method.

$= 5.5$

Q. In an aggregate mix, the propotions of Coarse aggregate, Fine aggregate and mineral Filler are 55%, 40% and 5% respectively. The Values of Bulk specific Gravity of the Coarse Aggregate, Fine Aggregate and Mineral Fillers are 2.55, 2.65 and 2.70. The bulk sp. gravity of the mix is ____

$$G = \frac{(55 \times 2.5) + (40 \times 2.65) + (5 \times 2.7)}{55 + 40 + 5}$$

$$\boxed{G = 2.59}$$



Q. The % of aggregate of FM 2·6 to be considered to be combined with CA of FM 6·8 for obtaining the agg. mix of FM of 5·4 is ——

Solution % of FA = x

% of CA = $1-x = y$

$$\Rightarrow 5\cdot4 = \frac{2\cdot6x + 6\cdot8(1-x)}{1}$$

$$\Rightarrow 5\cdot4 = \frac{2\cdot6x + 6\cdot8 - 6\cdot8x}{1}$$

$$\Rightarrow \quad x = 33\cdot33\% \text{ and } y = 6666\%.$$ (Ans.)

Q. The FM of FA is 3·4 and CA is 8·6. Agg. mix has FM of 6·7. Find Ratio of FA to CA?

Solution $$\frac{FA}{CA} = \frac{x}{1-x} = \frac{36\cdot53}{100-36\cdot53} = 0\cdot5748$$

FM - Fineness Modulus.

$$6\cdot7 = (3\cdot4x) + 8\cdot6(1-x)$$

$$\Rightarrow x = 0\cdot36538$$

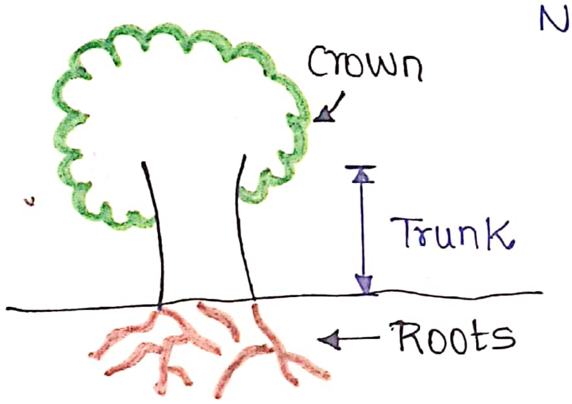
$$x = 36\cdot53\%$$ (Ans.)

5. **TIMBER** → Uncut and Large Fell down Tree

* **LUMBER** → Cut into standard sizes
[Converted Timber] [Sawed wood]

* **WOOD** → Organic Matter obtained from Tree

- Tree
  - → TRUNK — Imparts strength & Rigidity
  - → CROWN — Bears Leaves and Fruits.
  - → ROOTS — Foundation, Absorb H_2O and Nutrients from soil and gives to all parts



– CHARACTERSITICS OF GOOD TIMBER

1. A good heat and Electrical insulator.
2. Dark colour.
3. Uniform structure.
4. Narrow (very close) Annular Rings: Greater the strength.

- PROCESSING OF TIMBER

1. Felling of Trees → Natural
   → Man-made
   - Good Age of Trees to Fell Down : 50-100 Years *
     [Cut DOWN]
2. Seasoning
3. Conversion
4. Preservation.

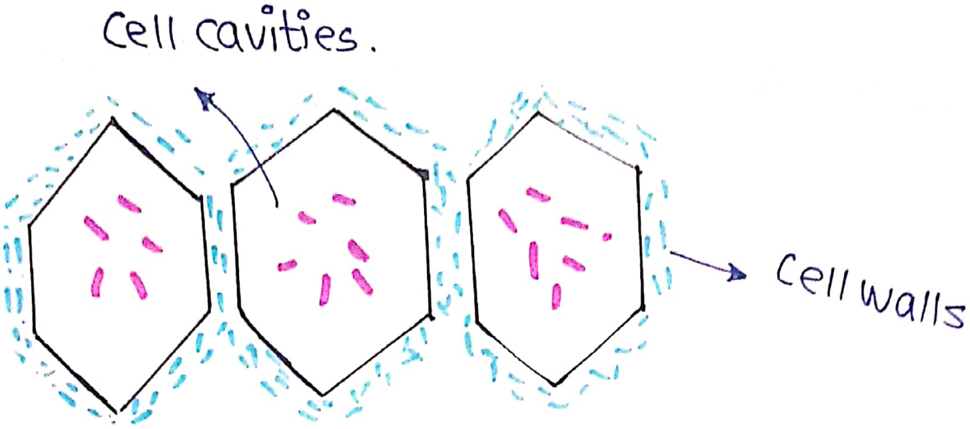
* SEASONING OF TIMBER

The process of drying out the water from wet or green Timber is <u>Seasoning</u>

→ Water tnt in Timber → In the form of SAP → Water + nutrients

→ Moisture in Cell Cavities : Free Water [Intracellular]

→ Moisture in Cell Walls : Bound Moisture [Inter Cellular]



- During Seasoning : Free Moisture Removed (evapourated) first.

- The point at which 100 %. Free moisture Lost is called <u>FIBRE SATURATION POINT</u>

$$\boxed{\text{Timber}} \xrightarrow[100-105^{\circ}C]{\text{OVEN}} \boxed{\text{Dry Timber}}$$

P%. of Mc

(W1) (Initial wt) (W2)

$$\therefore \boxed{P\% = \frac{W_1 - W_2}{W_2} \times 100}$$

- ADVANTAGES OF SEASONING

1. Durability of seasoned Timber > Unseasoned Timber.

2. Transportation Cost Reduction.

3.
   - Workability
   - strength
   - Hardness
   - stiffness

   → Increased

4, Less chances of Defects.

- TYPES OF SEASONING

NATURAL (Long Time Required and No control of factors)

- → Air Seasoning
- → Water seasoning

ARTIFICIAL

1, Boiling Seasoning
2, chemical / salt seasoning
3, Electrical seasoning
4. kiln seasoning
5. Mc Niells seasoning.

- **Chemical Seasoning** : Immense Timber in a Solution of soluble salts

↓

Dry Timber in Kiln

→ Adv : Inner & outer Timber seasoned Well.

Salts

- NaCl
- $FeSO_4$
- $Al_2(SO_4)_3$
- sod· phosphate
- Cal· Acetate

* CONVERSION OF TIMBER

The process of giving required shape and size to the Timber section is called as Conversion (aka Sawing)

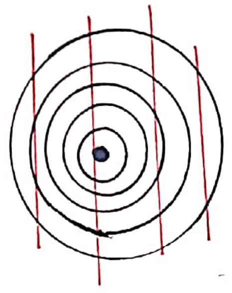
Conversion ↓ Olden Days ↓ MAN power

Conversion ↓ Modern Days ↓ MACHINES [saw cutting Machine]

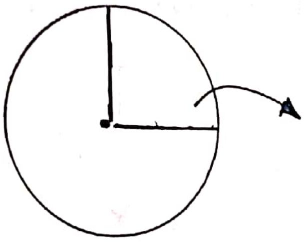
- TYPES OF SAWING (Cutting)

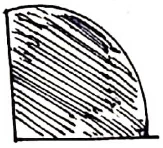
1. Oridinary / Flat / Slab sawing :

- Most Common Method in India
- Cuts are Made → Tangential to Annular Rings.



2, **Quatar Sawing** : Saw cuts made @ Right angles to each other.

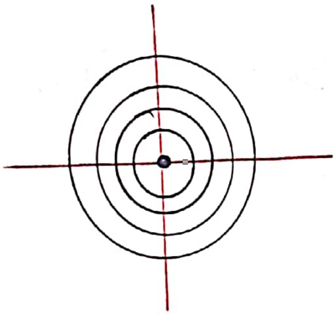


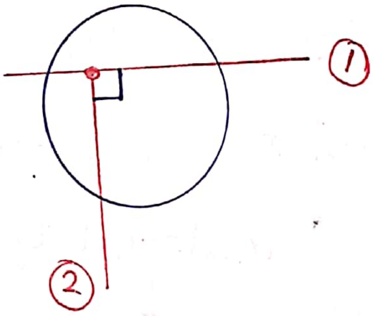


↓ Applicable for, Sections with indistinct Medullary Rings.

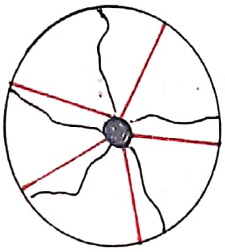
3, **Tangential / Plain / Flat Grained Sawing** :

→ Saw cuts made Tangential to Annular Rings which meet each other at Right angles. , Not used in ext works.





4 **Radial / Rift Sawing** : Method used to Hardwood.



- sawing Parallel to Medulary Rays (Radial Direction)
- Wastage ↑, Cost ↑
- Used for aesthatic purposes

* PRESERVATION OF TIMBER

- To maintain quality
- To increase strength and Durability
- To protect against Fungi and insect acts/attack

- METHOD OF APPLICATION OF PRESERVATOR

1, Brushing
2, Charing
3, Injecting under Pressure
4, spraying
5, Hot and cold open Tank Treatment

- TYPES OF PRESERVATIVE

(A)
1. Tar
2. Amm. Sulphate
3. $ZnCl_2$
4. Borax
5. sodi silicate

→ Resistance against FIRE

(B) Oil paints

(C) Solignum paints

(d) chemical salts ($CuSO_4$, $MgCl_2$, etc.)

(E) Creosite oil (distillation of Coal Tar)

(F) A S T U Treatment
→ against Termite Action.

A S T U — By Indian Forest Research Institute, Dehradun.

A → Arsenic Pentoxide ①

S → $CuSO_4$ (sulphate) ②

T → Termite

U → Unit

③ $K_2Cr_2O_7$ (or) $Na_2Cr_2O_7$

in 1 : 3 : 4 Ratio.

DEFECTS IN TIMBER

DUE TO SEASONING

- Bow
- Cup
- Warp
- Twist

DUE TO NATURAL FORCES

1. shakes →
   - Radial shakes
   - Cup "
   - Heart "
   - Ring "
   - Shear "
2. Knots
   - Loose Knot
   - Decayed "
   - Live "
   - Tight "
   - Round "
   - Dead "
3. Twisted Fibre
4. Druxiness

DUE TO INSECTS

DUE TO FUNGI

- Blue strain
- Dry Rot
- Brown Rot
- White Rot
- Heart Rot
- Wet Rot

DUE TO CONVERSION

1, Chip mark

2, Diagonal Grain

3, Wane

4, Torn Grain

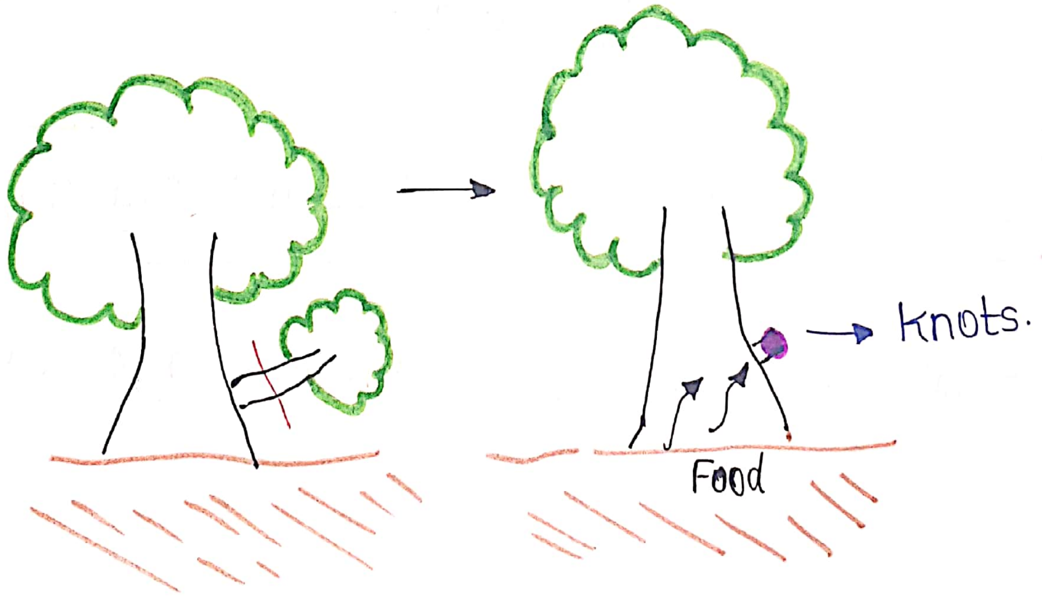
- Fungi Attack on Timber only when :

1. Moisture Capacity of Timber > 20%
2. Presence of Air and Warmth around Timber

→ **ROT** → Decay/Disease Caused to Timber [Chemical Decomposition]

→ **KNOT** → These are the bases of braches or limbs which are broken or Cutoff from Tree.

But, the portion recieves nourishment from the stem continuously for Long time and ultimately Results formation of Dark Hard Rings is called KNOTS.



6. CONCRETE

A composite material composed of :

1) Cement → Binding Material and gives strength.

2, Gravel (CA) → Strength

3, FA (sand) → Filler

$\left.\begin{array}{l}\text{2, Gravel (CA)} \to \text{Strength} \\ \text{3, FA (sand)} \to \text{Filler}\end{array}\right]$ Volume ↑, Cost ↓

4. Water → (i) Hydration ii) Workability iii) Plasticity

5, Admixtures → To improve Desired character.

Cement + FA + CA + Water + Admixture (If needed) → Concrete

* $\boxed{1\ m^3 \text{ Wet Concrete} = 1{\cdot}53\ m^3 \text{ Dry Concrete}}$

(Heat Released → Swelling → $\eta\uparrow \to$ Vol ↑)

Q Find Number of cement bags required for $5 m^3$ of concrete having mix Design of 1:3:6 by Volume.

Sol $5 m^3$ concrete = 1.53×5 Dry Volume

$= 7.65 \ m^3$

Ingrediant Volume : $7.65 m^3$ (Initially)

C : FA : CA
1 : 3 : 6

$$7.65 m^3 \text{ (Initially)} \downarrow 5 m^3 \text{ (wet)} \downarrow 7.65 m^3 \text{ (Dry)}$$

(on structure) $7.65 m^3$ (Dry)

$$\Rightarrow V_{cement} = \frac{1}{1+3+6} \times 7.65$$

$$\left[\underset{\text{cement (Here)}}{\underset{\downarrow}{V_x}} = \frac{\text{Propotion } x}{P_x + P_y + P_z} * \text{Total Volume} \right]$$

$$\Rightarrow V_{cement} = 0.765 \ m^3$$

But Vol. of 1 Cement Bag $= 0.0347 \ m^3$

$$\Rightarrow \text{No. of Cement Bags} = \frac{0.765}{0.0347} = 22 \text{ Bags}$$

$$\boxed{N = 22 \text{ Bags}}$$ (Ans.)

- CLASSIFICATION OF CONCRETE

ON THE BASIS OF BINDING MATERIAL

- Cement Concrete
- Lime Concrete
- Gypsum concrete

BASED ON STRENGTH

1- LOW STRENGTH :

$S \leqslant 20 N/mm^2$

2. MOD. STRENGTH :

$S : 20-40 N/mm^2$

3. HIGH STRENGTH :

$S > 40 N/mm^2$

BASED ON BULK DENSITY

(kg/m³)

1. EXTRA LIGHT wt:

$\rho < 500$

2. LIGHT Wt. CONCRETE :

$\rho : 500 - 1800$

3. DENSE Wt. CONCRETE :

$\rho : 1800 - 2500$

4. SUPER HEAVY WT. CONCRETE :

$\rho > 2500$

4. BASED ON PRESPECTIVE STRENGTH :

[Strength Determined through NDT]

→ All mix propotions are given.

	Grade of Concrete	Mix Propotions	Prespective strength (N/mm^2)
Nominal mix (as per IS 456)	M5	1 : 5 : 10	5
	M10	1 : 3 : 6	10
	M15	1 : 2 : 4	15
	M20	1 : 1.5 : 3	20
	M25	1 : 1 : 2	25

MANUFACTURING OF CONCRETE

1. **BATCHING**
   - → Volume Batching → M10 $100m^3$
     - ⓒ $10m^3$
     - Ⓢ $30m^3$
     - Ⓖ $60m^3$
   - → Weight Batching

→ M10 concrete of $100m^3$

Vol. of cement → $10m^3$?

$0.0347m^3$ 50kg cement

$$W_{cement} = 10 \times \frac{50}{0.0347}$$

$$= 1,44,09.22 \text{ kg}$$

2. **MIXING**
   - → Hand Mixing
   - → Machine Mixing

3. **TRANSPORTATION**

4. **PLACING**

5. **COMPACTION**

6. **FINISHING (UNIFORM SURFACE)**

7. **CURING**

MIX DESIGN

NOMINAL MIX
(upto M20 only)

- C : Agg : Water as per IS 456
- Volume Batching
- 1 : n : 2n
  C : FA : CA

STANDARD MIX
(M_5-M_{25})

- As per IS Code, Fixed Propotions
- Weight Batching
- Upto M25 only
  ↓
  1:1:2

DESIGN MIX
(from M25-M60)

- No fixed Propotions.
- Estimating the propotions based on Need and as per IS 10262

→ Design mix : M25 to M55 : oridinary Concrete

Mix ≥ M60 : High strength concrete

- Procedure of Mix Design

(IS 10262 : 2009)

1.] Determine Target Mean strength for Mix Propotions :

$$\boxed{f_m \text{ or } f'_{ck} = f_{ck} + 1.65\,\sigma}$$

f_m or f'_{ck} → [Target Mean Compressive str @ 28 days] (N/mm²)

f_{ck} → Characteristic Comp. strength @ 28 days (N/mm²)

σ → Std Deviation (N/mm²) → Is 10262

* Standard Deviation

σ

- For M10 and M15 → 3.5 N/mm²
- For M20 and M25 → 4 N/mm²
- For M30 to M60 → 5 N/mm²
- For > M60 → 6 N/mm²

2) **Selection of W-C Ratio :**

As per IS 10262

3, **Determine Water Content :** Water per kg of Cement

(a) From slump Cone Test.

(b) From Table (IS code)

↳ Based on Aggregate size.

Aggregate

Nominal max size	Max. Water content
10 mm	208 kg/m^3
20 mm	186 kg/m^3
40 mm	165 kg/m^3

→ For slump value of 25 mm

Slump Value	Water Extra
25 – 50 mm	0 %
50 – 75 mm	3 %
75 - 100 mm	6 %
100 - 125 mm	9 %

[NOTE :

For Every 25 mm additional slump Value

↳ Add 3 % additional Water]

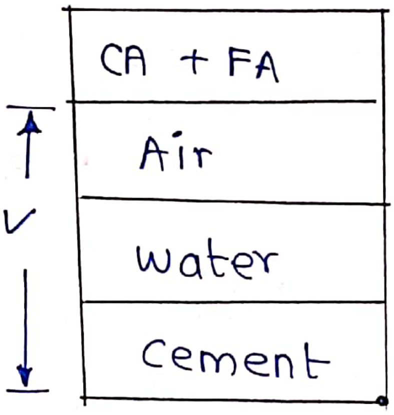
4. Estimation of Cement Content :

$$\text{Cement content (kg/m3)} = \frac{\text{Water Content}}{\text{W/c Ratio.}}$$

5. Estimation of CA & FA Content :

$$\boxed{V = \left[W + \frac{C}{Sc} + \left[\frac{1}{P} * \frac{fa}{Sfa}\right] \cdot \frac{1}{1000}\right]}$$

(FOR FA)



→ Where,

- V = Abs. Volume for Fresh concrete.
- W = Wt of water
- C = Wt. of cement
- Sc = Sp. Gravity of cement
- fa → Wt. of FA
- P → Fraction of FA in Total Aggregate

$$= \frac{FA}{FA+CA} = \frac{n}{n+2n}$$

- If no info given, $\left.\begin{array}{l} FA = 33.33\% \\ CA = 66.66\% \end{array}\right]$ Total Aggregates

→ For CA

$$\boxed{V = \left[W + \frac{C}{S_c} + \left[\frac{1}{1-P}\right] \frac{C_a}{S_{ca}} \right] \cdot \frac{1}{1000}}$$

$$\boxed{P = \frac{FA}{CA + FA}}$$

$$V_{concrete} = \left[\frac{W_w}{\rho_w} + \frac{W_c}{\rho_c} + \frac{W_{FA}}{\rho_{FA}} + \frac{W_{CA}}{\rho_{CA}} \right]$$

$$= V_w + V_c + V_{CA} + V_{FA} + V_{Air}$$

$$= \underset{\downarrow}{(V_A + V_w)} + \underset{\downarrow}{(V_c + V_{CA} + V_{FA})}$$

$$\boxed{V_{concrete} = V_{oids} + V_{solids}}$$

$$\boxed{\begin{array}{l} V_{Aggregate} = \underset{\substack{\downarrow \\ V_{concrete}}}{1} - \underset{(A+W)}{V_{voids}} - V_{cement} \end{array}}$$

Q. Determine the Volume of CA required to prepare $1m^3$ of M_{20} Nominal mix Concrete ?

Solution

$M_{20} \rightarrow 1 : 1.5 : 3 \longrightarrow$ Sum ①

Cement → x ①

$1m^3 = 1x + 1.5x + 3x$

$= 5.5x$

$1m^3$ concrete

⇓

$1.53 m^3$

Dry Volume

$\therefore x = \frac{1}{5.5} \times 1.53$

$= 0.278 \; m^3$

$1 \; m^3$ wet Concrete $\xrightarrow[\text{due to}]{\text{Formed}}$ $\boxed{1.5m^3}$ volume of Dry ingrediants

$CA = 3 \times 0.278$

$= 0.834 m^3$

Q Determine Wt of Cement required to prepare $1m^3$ of M_{20} Std. mix Concrete. Consider w/c ratio as 0.5 Density of Concrete 2400 kg/m³ ?

Solution

Concrete Mass $= \rho \times$ Volume

$= 2400 \times 1$

$= 2400$ kg.

→ C : FA : CA : Water

$x : 1.5x : 3x : 0.5x$

$= 6x$

$6x = 2400\ \text{kg}$

$$\Rightarrow x = \frac{2400}{6} = 400\ \text{kg}$$

$\boxed{x = 400\text{kg}}$ (Ans.)

Q. Determine the weight of Ingrediants required to prepare $2\ m^3$ of M15 standard mix concrete W:C as 0.6. Specific Gravity of cement FA, CA are given as 3.15, 2.6 and 2.5. respectively.

Solution M15 → 1 : 2 : 4 (Given)

$$2 = \left[\frac{x}{1.5} + \frac{2x}{2.6} + \frac{4x}{2.5} + \frac{0.6x}{1}\right] * \frac{1}{1000}$$

$\boxed{x = 608.51\text{kg}}$

- Cement = 608.51 kg
- FA = 1217 kg
- CA = 2434 kg
- water = 0.6x 608.51 = 365.106 kg

[NOTE:

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

P= wt of Cement ; Y= wt of FA ; Z = Wt of CA

$\left(\frac{W}{C}\right) \rightarrow$ Water Cement Ratio

Quantity of water $\boxed{W = 0.3p + 0.1y + 0.01z}$

Q calculate the quantity of water mixed for preparation of design mix [1:3:6] (by wt.) in which cement added is 300 Kg ?]

Solution

$$W = (0.3 \times 300) + (0.1 \times 900) + (0.01 \times 1800)$$

$$\boxed{W = 198 \text{Kg}}$$

→ TESTS ON CONCRETE

* WORKABILITY TEST

1. Slump Cone Test
2. Compaction Factor Test → $CF = \frac{\rho_{\text{partially Comp.Concre}}}{\rho_{\text{Fully Comp.Concrete.}}}$
3. Veebee Consistometer Test → Vee Bee Degree (seconds) $\propto \frac{1}{\text{Workability}}$
4. Flow Table Test.
5. Kelly Ball Test.

→ **Abram's Equation** : $S = \frac{A}{B^{w/c}} = \frac{96}{(7)^{w/c}}$

- S → Comp. strength (mpa)
- A → 96 N/mm^2
- B → 7

→ Gel-space Ratio (x) = $\dfrac{\text{Volume Of Hydrate Cement Paste}}{\text{Vol. Of Hydr. Cement} + \text{Vol. Of Capillary pores}}$

① $\therefore S = 240 \cdot x^3$ $\therefore \boxed{x = \sqrt[3]{\frac{S}{240}}}$

② Gel-Space Ratio $x = \dfrac{0.657\,C}{0.319\,C + W_o}$

- C → Wt of cement (g)
- W_o → Vol. of water mixing (mL)

[Specific Volume of cement → 0.319 mL/g]