Building Material

* Cement
Lime
Mortar
Bricks
Aggregates
Admixtures
* Concrete
* Timber

1) Cement :- [Binding Material]

Composition of cement →

→ Cement broadly consist of following two types of constituents :-

(i) Calcareous compounds {which contain calcium}
→ Lime, Chalk, Marine shells.

(ii) Argillaceous compounds {contains silica}
→ Clay, Marl, Shale.

Imp.

Constituents Present in OPC :-		%age composition.	
1) Lime	(CaO)	62-67	
2) Silica	(SiO_2)	17-25	
3) Alumina	(Al_2O_3)	3-8	
4) Calcium sulphate	($CaSO_4$)	3-4	→ in the form of gypsum
5) Iron oxide	(Fe_2O_3)	3-4	
6) Magnesia	(MgO)	1-3	
7) Sulphur	(S)	1-3	
8) Alkalies	(Na_2O, K_2O)	0.2-1	

For OPC only

Functions of Ingredient of the cement :-

1) Lime :- (62-67%) It imparts strength & Soundness (similar to compressibility) to the cement, if it is in excess, it makes the cement unsound & causes it to expand & disintigrate. & if it is in deficiency, strength of the cement is decreased & it causes the cement to set quickly.

Strength → resistance from impact to gradual loading

~~Toughness~~ Hardness → resistance to abrasion.

~~Hardness~~ toughness → Resistance to impact (sudden) loading.

2) Silica :- (17-25%)

→ It also imparts final strength to the cement.

→ If it is in excess, strength of the cement is increased, but it also increases the setting time of the cement.

Wherever, early setting is require, we need to change the consituent as (silica & lime are long setting constituents)

3) Alumina :- (3-8%)

→ It imparts quick setting property to the cement.

→ It acts as a flux & helps in reducing the clinkering temperature.

→ If it is in excess, it weakens the cement.

→ temp at which clinker are formed

→ The temp. at which clinckers of cement form is known as clinkering temperature.

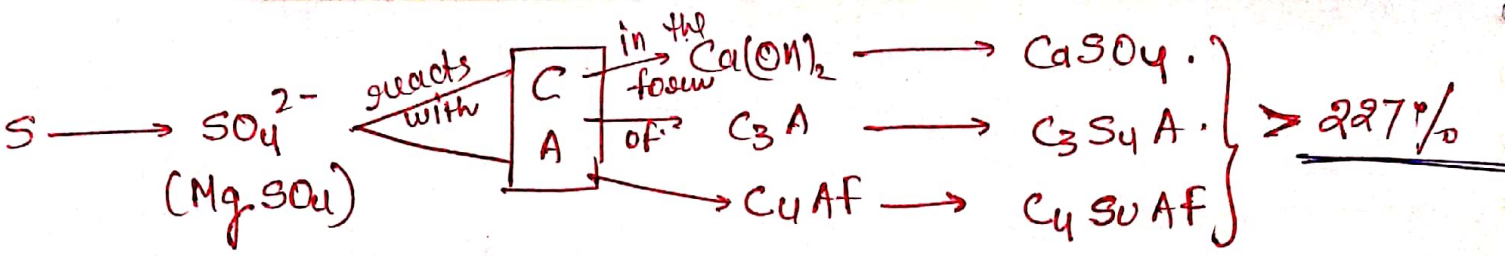
4) Calcium Sulphate :- (3-4%)
→ It is generally present in the form of gypsum. ($CaSO_4 \cdot 2H_2O$ · ($CaSO_4 \cdot 2H_2O$))
→ It helps in increasing the initial setting time of the cement.

5) Iron oxide :- (3-4%)
→ It imparts Strength, Hardness & colour to the cement.
colour → Reddish brown ting. is because of Fe_2O_3.

6) Magnesia :- (1-3%)
→ It also imparts Strength, Hardness & colour to the cement.
colour → yellowish ting
→ If it is in excess, it makes the cement unsound.

7) Sulphur :- (1-3%)
→ Sulphur in cement is responsible for volume changes, Hence it also leads to unsoundness in the cement.
unsoundness → change in vol.

8) Alkalies :- (0.2-1)
→ Alkalies in cement are responsible for staining and efflorescence of the structure in which it is used for construction.
staining → white or gray spots on structures where cement is use.
efflorescence → Des asthetic value



→ when these ingredients of the cement are ~~intercomm~~ interground & burnt they fuse with each other, leading to the formation of complex chemical compound which are not formed simultaneously & are ~~suffered~~ referred as ~~Bogues~~ Bouges compounds.

Bouges comp

1) Tricalcium Aluminate [$3CaO \cdot Al_2O_3$] [C_3A]
{Celite :- (4 - 14%)} ↓ no. of moles

→ It undergoes hydration within 24 hrs of the addition of the water in the cement.

→ It is responsible for flash setting of the cement & also leads to volume changes in it. Thereby is responsible for development of cracks in it. [↑ in the volume].

→ It releases max. heat of hydration during its formation.

→ Shrinkage takes place, bcoz, hydration occurs due to C_3A & volume of cement change takes place. as water get vaporises and vol ↓es.

2) Tetra calcium Alumino ferate [$4CaO \cdot Al_2O_3 Fe_2O_3$]
CuAf {Felite :- 10-18%} [C_4AF]

→ It also undergoes hydration within 24 hrs of the addition of the water in it.

→ It is observe to have worst cementing property.

→ It is of no engineering significance as it

does not imparts any property in the cement:-

3) Tri calcium silicate, $[3CaO \cdot SiO_2]$ $[C_3S]$
{Alite :- 45-65%}

→ It undergoes hydration within a week or so, after the addition of water into the cement.
→ It is responsible for development of early strength in the cement. Hence, if in any Engg. construction, early strength is required, proportion of C_3S is increased considerably.

Ex:- 1) cold weather concreting.
2) Pavement construction.
3) Pre-fabricated construction.
4) where form-work is to be reutilize for
5) Speedy construction.

→ It also increases the resistance of the cement against freezing & thawing → melting. by ↓es permeability of soil-1 (freezing)
→ It possess the best cementing property amongst all the bogues compounds.

4) Dicalcium silicate $[2CaO \cdot SiO_2]$ $[C_2S]$
{Belite :- 15-35%}

→ It undergoes hydration within an year or so also after the addition of water into the cement. Hence is responsible for development of progressive strength in it. or ultimate strength.
→ It also increases the resistance of cement against the action of chemicals.
→ If in any Engg. construction, progressive strength is required, proportion of C_2S is

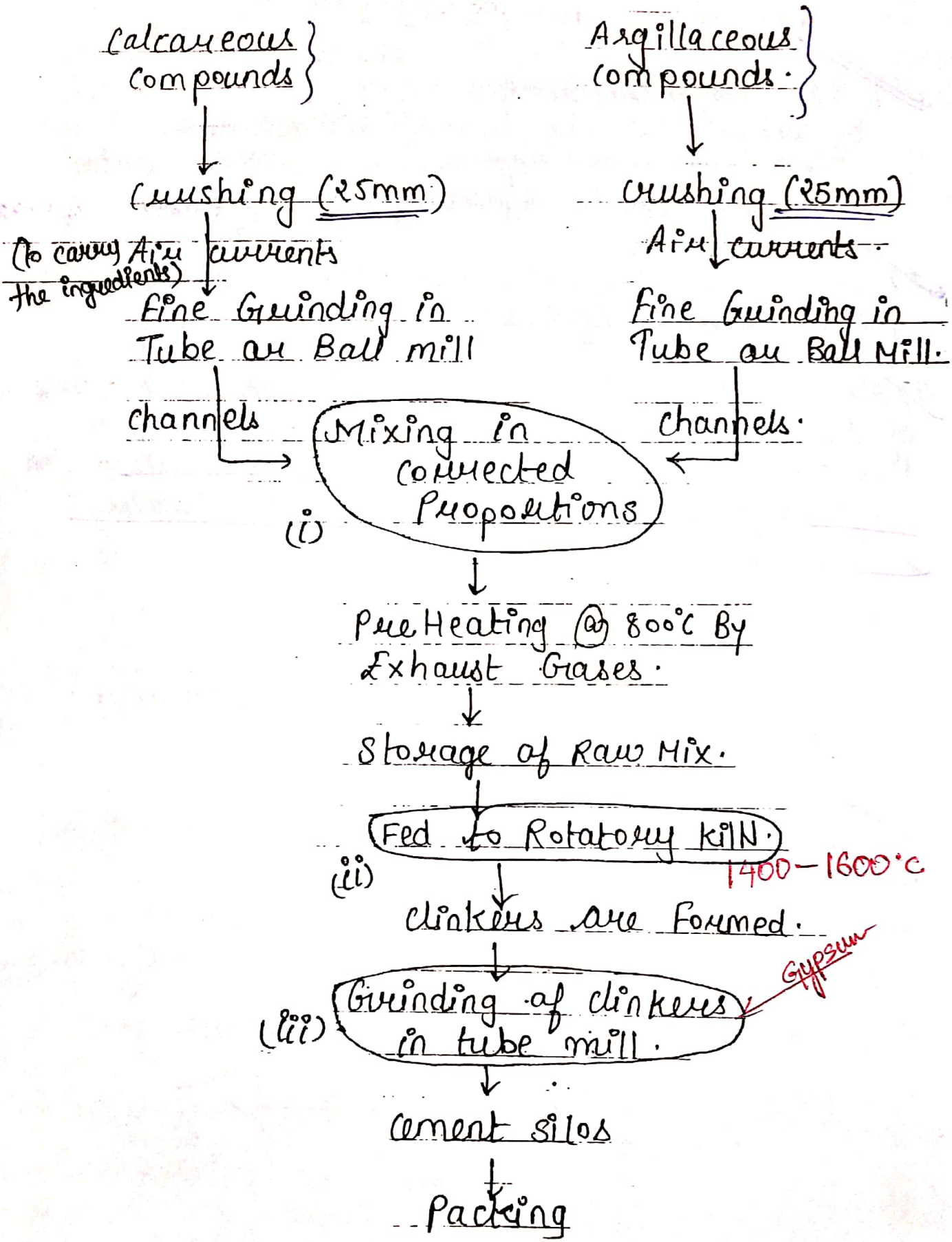
Manufacturing of Cement :-

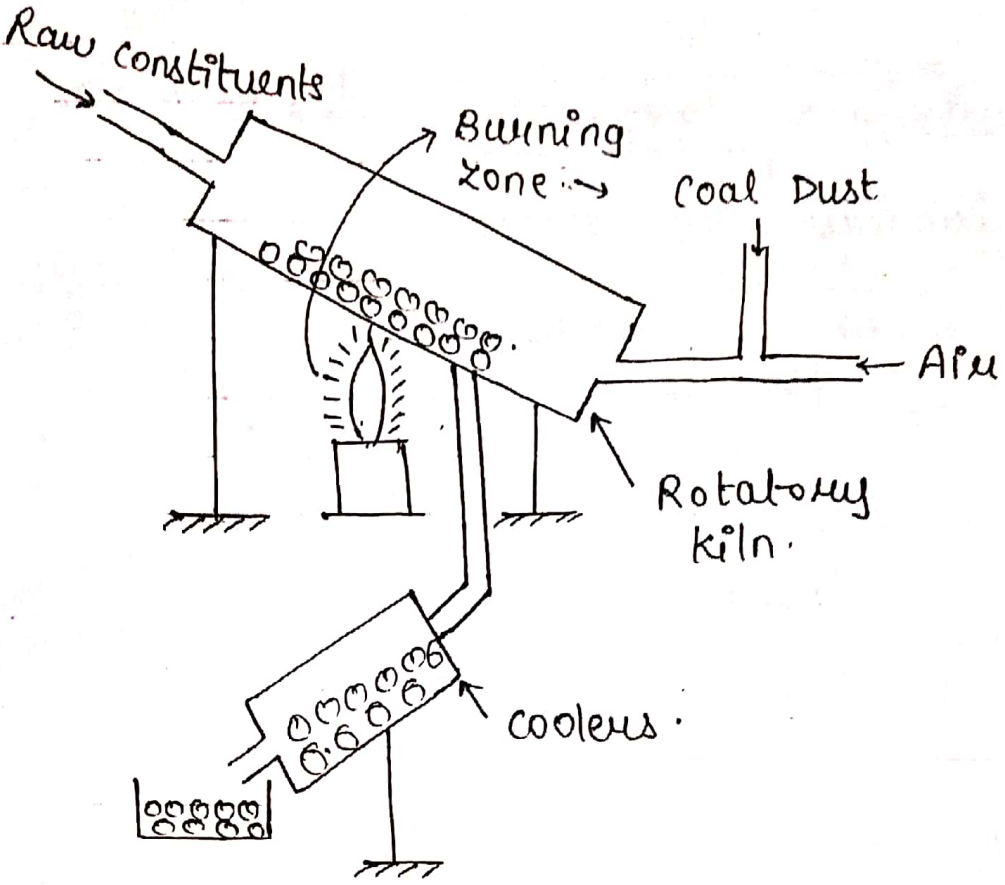
→ Manufacturing of the cement is carried out in three distinct operation.

1) Mixing of Raw ingredient.
2) Burning.
3) Grinding.

→ Manufacturing of the cement can be done by any of the following methods.

1) Dry Method (Process) [New Method] :-





2) Wet Process [Old Method] →

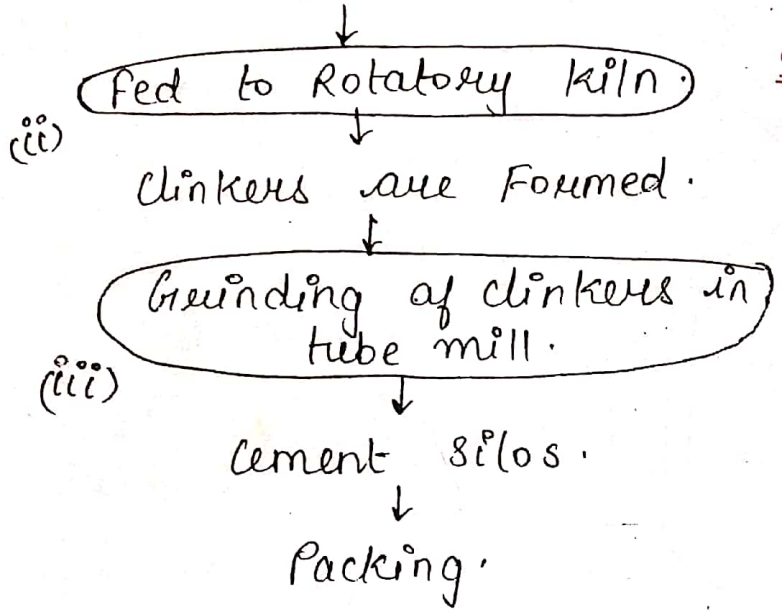
Calcareous Compounds
↓
Crushing (25mm)
↓
Storage Basins

Argillaceous Compounds.
↓ $+H_2O$.
wash mill ~~Crushing (25mm).~~
↓
Storage Basins.

→ Wet Grinding ← (in tube mill to form slurry)
↓
(i) Blending of slurry in corrected Proportion
↓
Storage of corrected slurry
↓

Advantage : quality is uniform coz of wet state mixing.

dis : more cost.



Special Type of Cement :-

2250

1) Rapid hardening Cement → 3250

- This is a type of cement which developes higher rate of gain of strength & must not be confused with quick setting cement which only sets quickly and strength = OPC
- Cement attain the strength at the age of 3 day equivalent to that attain by OPC in 7days;
- This higher strength (↑grindness) in initial stage is attributed to the higher fineness of the cement & increase the proportion of C_3S (Specific Surface Area should not be less than 3250 cm^2/gm & C_3S is approximately 56%).

3250
56%

- This cement find its application in
  - i) Prefabricated construction.
  - ii) Cold weather concreting.
  - iii) Emergency Repair work.
  - iv) Pavement construction.
  - v) Where formwork is to be reutilize for speedy construction.

2) Extra Rapid hardening Cement →

- The cement is formed by intergrinding rapid hardening cement clinkers with calcium chloride.

Earlier $CaCl_2$ was added in cement, but now as it increase corrosion in reinforcement, it is not used now-a-days.

- under normal condition proportion of $CaCl_2$ must not be greater than 2%.
- The cement must be mixed, transported, placed, compacted & finished within 20mins of the addition of the water in it.
- The strength of the cement is approximately 25% more than rapid hardening cement at the age of 1 or 2 days, 10 to 15% more at the age of 7 days.
- This rate of gain of strength in this cement reduces with age & at the age of 90 days strength of all OPC, Rapid hardening cement & Extra Rapid hardening cement is approximately same.

3) Sulphate Resisting Cement → Volume ch = 22%.

→ Sea water contain sulphur in excess & it leads to volume change. Sulphur is also found in soil, in sewage also sulphur is available therefore pitting is not done.

- OPC is highly suseptible (sensitive) to the attack of sulphates specially to that of $MgSO_4$ (Magnesium sulphate) which reacts with both, calcium hydroxide (as to form Calcium Sulphate & calcium aluminate to form calcium Sulpho-Aluminate. Vol. of which is approx.

227%.

227% more than its original volume, that leads to the development of the cracks in the structure in which it is used for construction.

- In order to avoid this proportion of Lime, & alumina is reduced in the cement. such that C3A is not greater than 5%. & 2C3A + C4AF is not greater than 25%.

- The cement find its application in →
  i) Marine construction
  ii) Sewage treatment works.
  iii) Foundation work.
  iv) In the construction of the pipes that are to be laid in the Marshy areas.

4) Super Sulphated Cement (Sul. low heat cement)

(type of Portland cement)

- The cement is prepared by intergrinding 80 to 85% granulated (powder) blast furnance slag, 10 to 15% hard burnt gypsm & 5% cement clinkers.

- The cement offers very high resistance against the attack of chlorides & sulphates.
  → Residue left after the extraction of (metal) cement is known as slag.
  → strength is less, resisting property is more. cost is less.
  → Applications are same as sulphate Resisting cement.

Strength of OPC > Super Sulphated cement

Pozz particles size of pozzolonic material is less than clay.

5) Portland Slag Cement →

- The cement is prepared by Intergrinding granulated blast furnace slag, hard burnt gypsm & cement clinkers in definate proportion.

- The cement offers →
  i) Low heat of hydration.
  ii) Higher resistance against the attack of chlorides & sulphates.
  iii) Better refinement of porous structure.
  iv) Higher water tightness.
  Lowers the permeability due to ~~more size~~ & lesser size of soil particles & lesser voids

6) Quick Setting Cement →

- The cement is obtain by adding small % of alumina in finely grinded cement clinkers & reducing the proportion of calcium sulphate. (means gypsm).

- The cement find its application in →
  i) Grouting operation.
  ii) under water concreting.

7) Low Heat Cement →

- The cement is prepared by reducing the proportion of C_3A & C_3S & increasing the proportion of

C_3S & C_3A → low heat of hydratn & decrease strength.

C_2S → increase strength.

C_2S to compensate the loss of strength (C_3A is approximately 5%, C_3S is approx. 46%, C_2S is approx. 34%).

- This cement also develop slower rate of gain of strength.
- Heat of Hydration of the cement at the age of 7 days is not greater than 65 cal/gram and at the age of 28 days is not greater than 75 cal/gram.
- The cement find its application in mass concreting
  Ex → Bridges, Hydraulic structures & dams.

8) Portland Pozzolana Cement →

- This cement is prepared by intergrinding cement clinkers with 10 to 15% pozzolonic material.
- Pozzolonic material is essentially celicious or Aluminus compound which in itself do not posses any cementous Property, but when finelly grinded in the presence of water, it reacts with calcium Hydroxide released during the hydration of the cement & leads to the formation of cementous compound. CSH gell

Ex → Blast Furnace Slag, Rice husk ash, Surkhi, fly ash or Charcoal.
↓
powder form of bricks.

Super sulphated cement is a type of portland slag cement, & portland slag cement is a type of pozzolana portland cement.

- This cement →
  - i) attains compressive strength with age.
  - ii) offers higher water tightness.
  - iii) offers higher resistance against the attack of chloride & sulphate.
  - iv) offers higher resistane against expansion.
  - v) offers higher plasticity
  - vi) Has Low heat of Hydration.

- The cement finds its application :-
  - i) Marine water for construction (structure)
  - ii) construction of pipes in marshy area.

↳ During storage we don't want reaction between water and cement.

9) Hydrophobic Cement → in costal area or humid area

- The cement is prepared by inter grinding cement clinkers with water repellant film forming substances like stearic acid & oleic acid.
- This water repellant film which is formed around the cement particles reduces the rate of deterioration of the cement due to long storage & transportation period.

10) IRS-T-40 cement → (Rapid hardening cement)
(Indian Railway Service)

- It is the special type of patienfed cement.

Setting in general → final setting time

Initial setting time if asked then mentioned Properly.

that is obtain by finely grinding the cement clinckers & increasing the proportion of C_3S in it inorder to attain higher rate of gain of strength as is required in the manufacturing of railway sleepers for Indian Railways.

11) High Alumina Cement →

- The cement is obtain by intergrinding the clinckers obtain by the calcination of boxite & Lime stone. (boxite is a one of alumina & Lime stone is a one of lime).

process of interaction of metal

- Proportion of Alumina in this cement must not be less than 32% & ratio of % of alumina to that of lime is in the range of 0.85 to 1.3.

- The cement offers higher initial setting time (3.5hrs) & lower final setting time (5hr) Hence, more time is available to work with the cement along with speedy construction.

- The cement can also resist high temperature.
- It can resist action of acids upto greater extent.

- It also offers higher rate of gain of strength as it attains 20% of its ultimate strength within a day & substantial portion of the ultimate