BUILDING MATERIALS

(40 ± 5 Marks)

Topics

- Cement — (Definite ques).
- Lime
- Mortar
- Concrete — (Definite Ques)
- Timber — (Definite Ques)
- Bricks

1. Cement

Composition of Cement

- Cement is found to consist of 2 basic ingredients
  (i) Calcareous Compound (Lime)
  (ii) Argillaceous Compound (Clay)

All ingredients (including ~~Mg~~) are present in their oxide form

			(%)
Major	Lime (CaO)	–	62 - 67
	Silica (SiO_2)	–	17 - 25
	Alumina (Al_2O_3)	–	3 - 8
	Calcium sulphate ($CaSO_4$)	–	3 - 4
	Iron oxide (Fe_2O_3)	–	3 - 4
	Magnesia (MgO)	–	1 - 3
	Sulphur (S)	–	1 - 3
	Alkalies (K_2O, N_2O)	–	0.2 - 1

Objective

Functions of different Ingredients of the Cement

1. **Lime**

   - It imparts strength & soundness to the cement. If it is in excess it makes the cement unsound, causes it to expand & disintegrate. If it is in deficiency, strength of the cement is reduced and it sets quickly.

2. **Silica**

   It also imparts strength to the cement. If it is in excess, strength of the cement is increased along with the setting time.

3. **Alumina**

   It imparts quick setting property to the cement. It acts as a flux (aid) & helps in lowering the clinkering temperature.
   If it is in excess it also weakens the cement.

4. **Calcium Sulphate**

   It is generally present in the form of gypsum. It helps in increasing the Initial setting time of the cement.

5. Iron Oxide

It imparts colour, strength & hardness to the cement.

6. Magnesium Oxide → characteristic colour → Yellow

It also imparts colour & hardness to the cement. If it is in excess it makes the cement unsound.

7. Sulphur

It also imparts unsoundness to the cement

8. Alkalies

It causes efflorescence (→ ability to react with water vapour) and staining of the structure in which it is used for construction.

$MgO \neq 5\%$, $K_2O \neq 2\%$.

Bouges Compounds

When water is added into the cement. It reacts with the ingredients chemically & leads to the formation of complex chemical compounds which are not being formed simultaneously. These are referred as Bogues Compounds

(i) Tri Calcium Aluminate ($3CaO.Al_2O_3$) (C_3A) (4-14% by wt.)

It is formed within 24 hrs of the addition of water into the cement & is responsible for Evolution of maximum heat of hydration

↓

during chemical rxn, heat is

(ii) Tetra Calcium Alumino Ferrate ($4CaO.Al_2O_3.Fe_2O_3$) (C_4AF) (10 – 18%) by wt.

It is also formed within 24 hrs of addition of water into the cement. It is responsible for high heat of hydration in the initial stages.

(iii) Tri Calcium Silicate ($3CaO.SiO_2$) (C_3S) (45–65%) by wt

It is formed within a week or so after the addition of water into the cement and is responsible for Early development of the strength in the cement.

(iv) Di Calcium Silicate ($2CaO.SiO_2$) (C_2S) (15–35%)

It is formed within an year or so after the addition of water into the cement & is responsible for progressive steugth of the cement

Heat of Hydration associated with these Bouges Compounds are as follows:-

Compound	Heat of Hydration (Cal/gm) 3 days	90 days
C_3A	210	310
C_4AF	70	100
C_3S	60	105

Heat of Hydration of Cement =

$$(H) = a A + b B + c C + d D$$

- a, b, c, d → % of respective compounds
- A, B, C, D → Heat of Hydration of respective compounds

Note:- Depending upon the Engg. construction, proportion of C_3S & C_2S can be altered to attain the desired property in the construction.

If strength is requd. in initial stages, like in cold weather concreting, Pavement construction, Road repair work, Grouting, where formwork is to be reused, Pre fabricated structures, proportion of C_3S is increased, and if strength is requd. is later stages like in Hydraulic structures, bridges etc. proportion of C_2S is increased.

→ About 24 % weight of water is required by C_3S for complete hydration.

→ About 21 % wt of water is required by C_2S for complete hydration.

→ In general 23 % wt. of water is requd. by the cement for complete hydration.

→ Appox 15 % of the water is Embedded in the Gel pores of the cement which is not available