UNIT - 5

Engineering Materials

Cement:

concrete is most widely used non-metallic material construction of building dams, bridges etc in concrete cement is the essential material which binds sand and rock when mixed with water. cement is a dirty greenish heavy powder and finds its importance as a bulding material - It can be described as materials possessing adhesive and cohesive properties and capable of bonding materials like stones, bricks building blocks etc. cement has the property of setting and hardening in the presence of water.

The essential constituents of cement used for constructional purpose are compounds of calcium (Calcareous) and Al + Si (Argillareous)

portland cement: It is most widely used non metallic material of construction. It is a mixture of calcium silicates and calcium aluminates with small amount of gypsum.

The name portland cement is used because this powder on mixing with water gives a hard stone like mass which resemble portland cement rock.

properties: All portland cements are hydraulic in nature.

Composition of portland cement

calcium oxide (CaO) — 60 - 70%.

Silica (SiO_2) — 20 - 24%.

Alumina (Al_2O_3) — 5 - 7.5%.

magnesia (MgO) — 2 - 3%.

Ferric oxide (Fe_2O_3) — 1 - 2.5%.

Sulphur trioxide (SO_3) — 1 - 1.5%.

Sodium oxid (Na_2O) — 1%.

potassium oxide (K_2O) — 1%.

Raw materials Raw materials required for the manufacture of portland cement are

1) Calcareous materials CaO [Eg:- lime stone]

2) Argillaceous materials Al_2O_3 and SiO_2 [Eg: clay]

3) powdered coal (or) fuel oil

4) Gypsum ($CaSO_4 \cdot 2H_2O$)

functions of the ingredients in cement

1) Lime: Lime is the principle constituent of cement. Its proportion must be properly regulated excess of lime reduces the strength of cement. because its makes the cement to expand and disintegrate Lesser the amount of lime than required also reduces the strength of cement because of quick setting.

2) silica: gives strength to cement

3) Alumina: It is responsible for the setting action of cement. Excess of alumina makes the cement quick setting.

4) Iron oxide: It provides colour, strength and hardness to the cement.

5). Gypsum: It acts as a retarding agent for quick setting of cement.

Setting and hardening of Cement

Cement has the property of setting to hardening after being mixed with water which is called cement paste. The process of solidification involves setting and then hardening.

* Setting is defined as stiffening of the original cement paste due to initial gel formation.
* Hardening is development of strength due to crystallisation. The strength developed by cement paste at any time depends upon the amount of gel formed and the extend of crystallisation.

Chemical reactions involved in setting and hardening

* The initial setting of cement paste is mainly due to the hydration of tricalcium aluminate (C_3A) and gel formation of tetra calcium alumino ferrite (C_4AF).

$3CaO\,Al_2O_3 + 6H_2O \longrightarrow 3CaO\,Al_2O_3\,6H_2O + 880\ kJ/kg$

(Tricalcium aluminate) — crystals.

$C_3A + 6H_2O \longrightarrow C_3A\,6H_2O + 880\ kJ/kg$

Tricalcium aluminate — (hydrated tricalcium aluminate) (crystalline)

$4CaO\,Al_2O_3\,Fe_2O_3 + 7H_2O \longrightarrow 3CaO\,Al_2O_3\,6H_2O + CaO\,Fe_2O_3\,H_2O + 420\ kJ/kg$

(Crystalline) (Gel)

(Tetra calcium alumino ferrite)

$C_4AF + 7H_2O \longrightarrow C_3A\,6H_2O + CFH_2O + 420\ kJ/kg$

Crystalline. Gel

* The dicalcium silicates starts hydrolysing to tobermonite gel (which pusses a very high surface area and thus very high adhesive property). which also contributes to initial setting.

$2[2CaO\,SiO_2] + 4H_2O \longrightarrow 3CaO\,2SiO_2\,6H_2O + Ca(OH)_2 + 250\ kJ/kg$

Dicalcium silicate — Tobermonite gel — Crystalline Calcium

$2C_2S + 4H_2O \longrightarrow C_3S_2\,6H_2O + Ca(OH)_2 + 250\ kJ/kg$

* The final setting and hardening of cement paste is due to the formation of tobermonite gel and crystalisation of calcium hydroxide and hydrated tricalcium aluminate.

$2[3CaO\ SiO_2] + 6H_2O \longrightarrow 3CaO\ 2SiO_2\ 3H_2O + 3\ Ca(OH)_2 + 500\ kJ/kg$

Tri calcium silicate — Tobermonite gel — Calcium hydroxide Crystalline

$2C_3S + 6H_2O \longrightarrow C_3S_2H_2O + 3\ Ca(OH)_2 + 500\ kJ/kg$

During the setting and hardening of portland cement some amount of heat is liberated due to hydration and hydrolysis reaction on an average the quantity of heat evolved during complete hydration of cement is of the order of 500 kJ/kg

$C_3A > C_3S > C_4AF > C_2S$.

878 502 418 251 kJ/kg.

Steps during setting and hardening of cement.

When water is added to cement at first hydration of tricalcium aluminate (C_3A) and tetra calcium alumino ferrite. (C_4AF) takes place.

Cement + water → (1 day) → hydration of C_3A and C_4AF → (7 days) → Gelation of C_3S → (28 days) → Gelation of C_2S and C_3S

Lubricants

Lubricant: Lubricant is a substance used in between two moving surfaces to reduce friction.

Characteristics of a good lubricants

- A good lubricant should not undergo any decomposition, oxidation, Reduction at high temperature.
- A good lubricant should have higher flash and fire points than the operating temperature.
- A good lubricant should have high oiliness, viscocity index, anidine point.
- A good lubricant should not corrode the machine parts.

Classification of lubricants

Lubricants are classified on the basis of their physical state.

1) Liquid lubricants
2) Semi - solid lubricants
3) Solid lubricants.

1) Liquid lubricants

a) Vegetable oil – eg: palm oil, castor oil etc.

b) Animal oil – eg: whale oil, tallow oil etc.

c) Mineral oil – eg: petroleum fractions.

d). Synthetic lubricants eg:- silicones, poly glycol ether.

e) Blended oils (or) compounded oils eg:- mineral oils with various additives.

2) Semi-Solid lubricants

eg: Greases, valelines etc.

3). Solid lubricants.

eg: Graphite, molybdenum disulphide etc.

properties of Lubricants

Flash and fire point

flash point: Flash point is defined as the lowest temperature at which the oil gives off enough vapour that ignite for a moment, when a small flame is brought near it.

→ Fire point: Fire point is defined as the

lowest temperature at which the vapour of the oil burns continuously for atleast 5 seconds when a small flame is brought near it.

* Generally the fire point is 5 - 40°c higher than flash point.
* A knowledge of flash and fire point is useful in providing protection against fire hazard during transport and storage.
* Lubricating oils of paraffinic base possess higher flash points than those of naphthenic base.
* A good lubricating oil should have flash and fire points higher than the operating temperture of the machine.

cloud and pour point

cloud point: when an oil is cooled slowly the temperature at which the oil becomes cloudy in appearance is called its cloud point.

pour point: The temperature at which the oil ceases to flow or pour is called its

pour point.

* most of the petroleum based lubricating oils contain dissolved paraffin wax and asphaltic impurities.

* when the oil is cooled these impurities undergo solidification which cause Jamming of the machine. So the cloud and pour points indicate the stability of the lubricants in cold conditions.

* A good lubricants must have low cloud point and pour point.