Subject- Building Material
UCE-309

Cement

Lecture - 1

Course Coordinator
Dr. Raju Sharma
Assistant Professor
Department of Civil Engineering
Thapar Institute of Engineering and Technology
Patiala, Punjab

Content

- History of Binding Material
- Chemical Composition of Cement
- Function of Various Constituents of Cement
- Selection of Raw Material

Introduction

- In the mid eighteenth century ***John Smeaton*** discovered that certain impure limes exhibited the hydraulic properties. That is, they contained reactive silicates and aluminates, which could react with water to yield durable hydrates, which resisted the action of water. ***Smeaton*** used this material in the mortar used to construct the Eddystone Lighthouse in 1759.

Moir G, Advanced concrete Technology https://doi.org/10.1016/B978-075065686-3/50277-9

Introduction

- Lime was the ***binding material*** used in building construction till the second quarter of 19th century. It was in 1824 that Joseph Aspidin, invented a new cementing material.

- It was obtained by burning together **fixed proportions** of *limestone* and *clay* at very high temperatures and reducing the product to a very fine powder.

Duggal SK, Building Materials, New Age India Publisher

Introduction

- He obtained the patient under the name of ***Portland Cement on the date of 21 Oct. 1824***. The name "Portland" was given to it by its inventor (John Aspdin of Leeds, UK, in 1824) because he wished to imply that the cast material had the properties of Portland stone.
- In 1914, the Indian Cement Co. Ltd. Which Was established at Porbander (Gujarat) delivered 1000 tons of Portland cement.
- A three storeyed structure built at Byculla, Bombay is one of the oldest RCC structures using Portland cement in India.

Shetty MS, Concrete Technology Theory and Practice, S. Chand and Company Ltd.
Claisse PA, Civil Engineering Materials

Introduction

- A concrete masonry building on *Mount Road* at *Madras (1903),* the *har-ki-pahari bridge* at *Haridwar (1908)* and the *Cotton Depot Bombay*, then one of the largest of its kind in the world (1922) are some of the oldest concrete structures in India.

Shetty MS, Concrete Technology Theory and Practice, S. Chand and Company Ltd.

Introduction

- Now, it is manufactured almost in all the major countries of the world. It has acquired a global acceptance being ranked next to iron and steel only. It is manufactured in about 40 varieties.

Introduction

- The *German standard specification* for *Portland cement* was drawn in *1877*.
- The *British standard specification* was first drawn up in *1904*. The first ASTM specification was issued in *1904*.
- Standard IS 269 (OPC, 33 grade –specification) was first published in 1951 and subsequently revised in 1958, 1967, 1976 and 1989. This revision incorporates the experience gained with the use of this standard and brings the standard in line with the latest developments in this field.

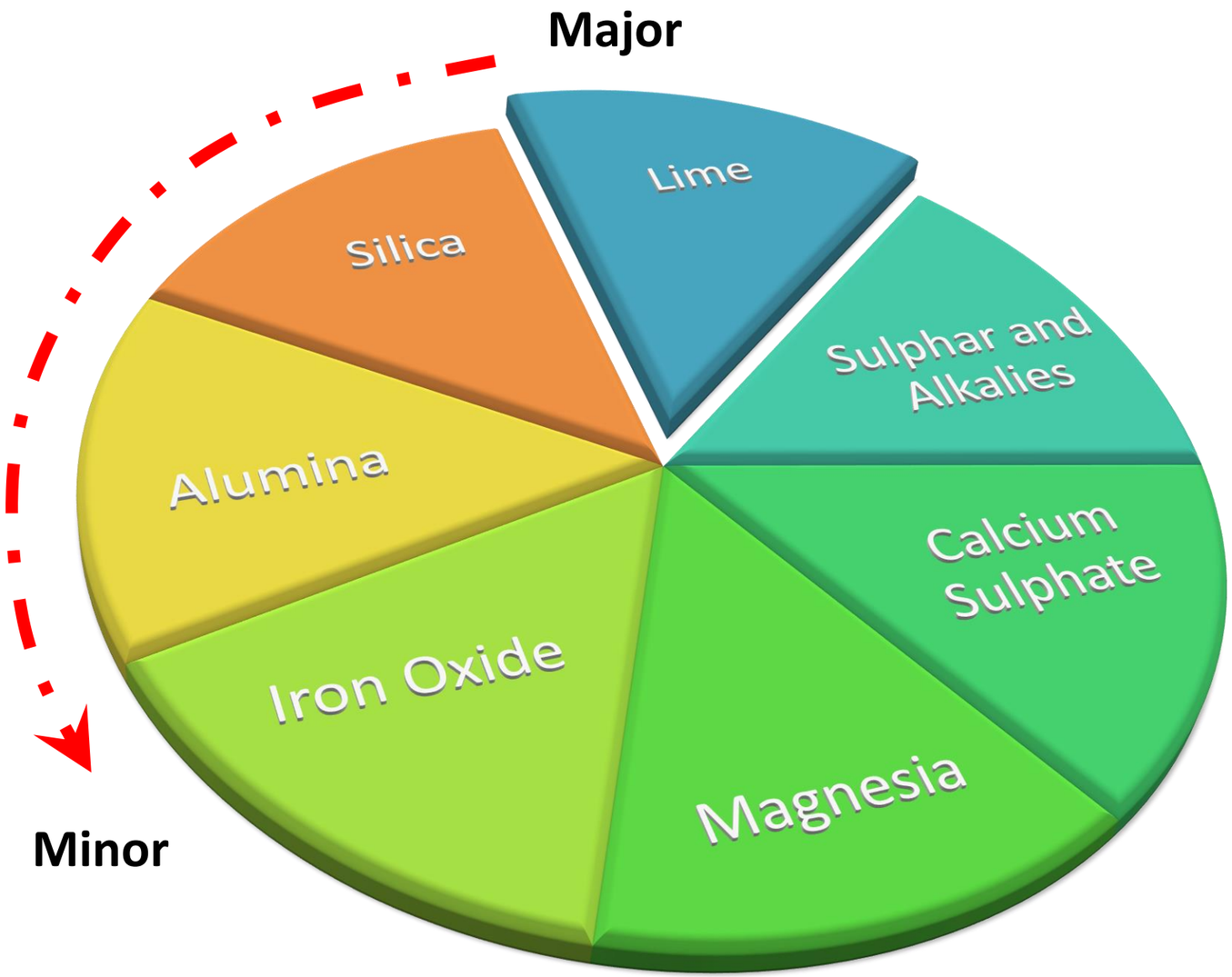
Definition of Ordinary Portland Cement (OPC)

- **The Ordinary Portland Cement (OPC) is reserved for a cement which is** : an **extremely finely ground product** obtained by burning together at high temperature specifically proportioned amounts of calcareous and argillaceous raw material, adding nothing else to the burnt product except gypsum in small percentage.

Ingredients of Portland Cement (OPC)

- **Calcareous** – **Lime Stone** or **Calcium Carbonate ($CaCo_3$)**
- **Argillaceous**- **Clay**
- All cement also contain minor proportions of **alumina, iron oxide**, **magnesium oxide** and **calcium sulphate**.

Chemical Composition of Cement



Chemical Composition of Cement

Composition of Portland Cement

S. No	Ingredient	Limits %
1	Lime (CaO)	60-66
2	Silica (SiO_2)	18-25
3	Alumina(Al_2O_3)	03-08
4	Iron Oxide (Fe_2O_3)	01-05
5	Magnesia(MgO)	01-04
6	Calcium sulphate ($CaSO_4$)	03-05
7	Sulphar	01-02
8	Alkalies	01-02

Functions of Various Constituents of Cement

- **Lime (Cao)**

1. **Major constituents** of cement.

2. Should be within the permissible range

3. ***Calcium oxide*** of cement **combines** with **silica** from clay and forms the **tri-calcium** and **di-calcium silicate** on burning

Functions of Various Constituents of Cement

which are mainly responsible for the setting and hardening properties of cement.

- Excess proportions of Lime makes cement unsound.
- Smaller amount than the desired limits, **cement is poor in strength and sets quickly**.

Functions of Various Constituents of Cement

- **Silica (SiO_2)**

1. Second most important constituents and is **responsible for the strength of the cement.**

2. Excessive silica- cement will be **stronger** but **take much time to set and hardened** .The source of silica in the cement is clay which is hydrous aluminium silicate.

Functions of Various Constituents of Cement

- **Alumina (Al_2O_3)**

1. It combine with other constituents to form **aluminates** that are **responsible** for **quick setting of cement**.
2. When present in excess, alumina will render the cement highly quick setting. Moreover, such cement will be poor in strength.
3. In lower proportions, the setting quality of cement will be affected

Functions of Various Constituents of Cement

- **Iron Oxide (Fe_2O_3).**

1. Responsible for the color of the cement to some extent. It forms compound with other ingredients that give additional strength and hardness to the cement.

Functions of Various Constituents of Cement

- **Calcium Sulphate ($CaSO_4$)**

1. Added to the cement after the burning stage in the form of rock gypsum ($CaSO_4, 2H_2O$). It act as a retarder, that is, it prolongs the initial setting time of cement.

Functions of Various Constituents of Cement

Absence of Gypsum

Cement will be very quick setting: it will set within a few minutes after mixing with water.

Functions of Various Constituents of Cement

- **Magnesia (MgO)**

1. Present in small proportions, magnesia is useful in imparting color and hardness.

2. Higher amounts, however, magnesia introduces undesirable qualities such as delayed setting and expansion resulting in cracking of the set cement.

Functions of Various Constituents of Cement

- Sulphur and Alkalies are considered impurities in cement and their content must not increase beyond the permissible limits.

Functions of Various Constituents of Cement

- The aforementioned ingredients of cement undergo **complex reactions** during the **burning stage** in the manufacturing process. The burnt products, as it comes out of the cement kilns is called CLINKAR.
- Various **compounds** identified in this clinker and their functions are of cement kilns is called in determining the quality of the **portland cement**.

Clinker

Clinkar

Brief about the Functions of Ingredients

Oxide	Function	Composition (%)
CaO	Controls Strength and soundness. Its deficiency reduces strength and setting time	60 – 65
SiO_2	Gives Strength. Excess of it causes slow setting.	17-25
Al_2O_3	Responsible for quick setting. If in excess, it lowers the strength	3-8
Fe_2O_3	Gives colour and helps in fusion of different ingredients	0.5-6
MgO	Imparts colour and hardness. If in excess, it causes cracks in mortar and concrete and unsoundness	0.5-4
Na_2O+K_2O	These are residues, and if in excess cause effloresce and cracking	0.5-1.3
TiO_2,		0.1-0.4
P_2O_5		0.1-0.2
SO_3	Make cement sound	1-2

Notes: 1. The rate of setting of cement paste is controlled by regulating the ratio $SiO_2/(Al_2O_3+Fe_2O_3)$
2. Where development of much heat of hydration is undesirable, the silica content is increased to about 21%, and alumina and iron oxide contents are limited to 6% each.
3. Resistance to the action of sulphate water is increased by raising further the silica content to 24 % and reducing the alumina and iron contents to 4% each.

Material Selection for Manufacturing Process

- This can be discusses conveniently under two headings:

1. Selection of Raw Material
2. Manufacturing Methods

1. Raw Material

Most important raw material required in the manufacture of Portland Cement are: *Limestone, Clay, Gypsum, Fuel and* ***Water*** *(in wet Process).*

A. Lime stones

These are sedimentary rocks, made up of calcium carbonate ($CaCO_3$).Usual impurities in lime stones are those of iron oxides, silica and alkalis. All lime stones are therefore not suitable for manufacture of Portland cement. It is essential that limestone selected for manufacture of cement should not contain:

Material Selection for Manufacturing Process

- Magnesium Carbonate… More than 5 %
- Free Silica… Even in small proportion
- Iron Sulphates… More than 3 %.

B. Clay Rocks

These are also sedimentary rocks made up mostly of hydrated silicates of Aluminum. Like limestone, they also contain some impurities as Iron oxides, free silica, alkalis and magnesia. Clay must not contain these impurities beyond the permissible limits.

C. Gypsum

it is generally added in very small amount **(2% by weight)** to the burnt cement (called Clinker) ***after it is taken out from the kiln and before it is sent for grinding***. Gypsum is a **sedimentary rock** having a composition of **calcium sulphate**. It is added for imparting a **retarding effect in setting of cement**. It is known that **without gypsum, the cement would set within minutes after adding water into it**. Adition of gypsum at the manufacturing time, however, increase the initial setting time to desirable limits

Summary

- ✓ The history of cement is discussed in this lecture.
- ✓ The detail of chemical constituents of cement is studied
- ✓ The function of each compound of cement is discussed in detail
- ✓ The selection of raw material to prepare the cement is studied

THANK YOU