I. INTRODUCTION

CHAPTER I

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I.1. Introductory Remark:

I.1.1. Portland cement[1]

Portland cement is made by heating a mixture of Limestone and Clay, or other materials of similar bulk composition and sufficient reactivity, ultimately to a temperature of about 1450 °C, partial fusion occurs, and nodules of clinker are produced. The clinker is mixed with a few percent of gypsum and finely ground to make the cement. The gypsum controls the rate of set and may be replaced by other forms of calcium sulphate. Some specifications allow the addition of other materials at the grinding stage. The clinker typically has a composition in the region of 67 % CaO, 22 % SiO_2, 5 % Al_2O_3, 3 % Fe_2O_3 and 3 % of other components and normally contains four major phases, called Alite, Belite, Aluminate phase and Celite. Several other phases, Such as alkali sulphates and calcium oxide are normally present in minor amounts.

"Alite" is the most important constituent of all ordinary Portland cement (OPC), it constitutes 50 – 70% of clinker. It is Tri-calcium silicates (3CaO SiO_2), (C_3S). Modified in composition and crystal structure by incorporation of foreign ions, especially Mg^{+2}, Al^{+3}, and Fe^{+3} it reacts quickly with the water, increasing the early strength.

The C_3S sets in a few hours, attains half of its strength in one week and develops medium heat of hydration (120 cal /g)[2].

"Belite" constitutes 15 – 30 % of ordinary Portland cement clinker. It is di-calcium silicate (2 CaO SiO_2), (C_2S) modified by incorporation of foreign ions and normally present wholly or largely as the ß - polymorph, it reacts slowly with water, thus contributing little to the strength during the first 28 days, but substantially to the further increase in strength that Alite and pure Belite are about the same under comparable conditions. It develops small heat of hydration (62 cal/g).

"The Aluminate phase" constitutes 5 - 10 of most ordinary portland cement clinkers. It is Tri - calcium Aluminate (3 CaO Al_2O_3), (C_3A). Substantially modified in composition and sometimes also in structure by incorporation of foreign ions, especially Si^{+3}, Fe^{+2}, Na^+ and K^+. It reacts rapidly with water, and can cause undesirable rapid setting unless a set controlling agent, usually gypsum is added. Develops much heat of hydration (207cal/g) and has a poor resistance to sulphate and sea water attack [3].

"The Ferrite phase" "Celite" makes up 5 - 15 % of normal Portland cement clinkers[2]. It is Tetra - calcium Alumino ferrite (4 CaO Al_2O_3 FeO_3), (C_4AF) substantially modified in composition by variation in Al/Fe ratio and incorporation of foreign ions. The rate at which it reacts with water appears to be somewhat variable, perhaps due to different in composition or other characteristics, but in general is high initially and intermediate between those of Alite and Belite at later stages. It shows moderate heat of hydration (80cal/g).

The most important standard types of Portland cement are:

1 - Normal or Ordinary Portland Cement (OPC)

This is a general purpose cement, suitable for all uses when the special properties of other types are not required, the cooled clinker typically contains four compounds in the approximate proportions[3] :

C_3S = 55 %, ß-C_2S = 20 %, C_3A= 15 % and C_4AF = 10 %.

2 - Rapid Hardening Portland Cement (high early strength)

This cement is similar to OPC, but it is normally ground finer (specific surface area equal at least 3300 - 4000 cm^2/g) than OPC (2500 - 3000 cm^2/g) and slightly alter in its composition[3, 4]. Its strength is more rapid (gives high strength in 24 hours) than OPC (in 3 days), so it sets and hardens (within a few minutes) much quicker than OPC, but the ultimate strength is lower.

3 - Low Heat Portland Cement

It is the best type in the construction of large dams or in the lining of oil wells, because it has the lowest heat of hydration, so that the chances of developing cracks latter are minimized. Slower heat evolution can be achieved by coarser grinding, lowering the contents of Alite and Aluminate phase or partially replacing the cement by fly ash or other materials. The rate of strength development is lower than that of OPC.

C_3S = 35 %, C_3A = 7 % and ß-C_2S = 40 %[3].

4 - Sulphate Resisting Cement (SRC)

Destructive expansion from reaction with sulphates can occur not only if the latter are present in excessive proportion in the cement but also from attack on concrete by sulphate solutions.

The reaction involves the C_3A with sulfite ion producing the ettringite phase (its volume is higher than the original hardened phase by 227th time).

In the SRC the C_3A must be reduced to less than 3%. This occurred by increasing Fe_2O_3 / Al_2O_3 ratio.

5 - White Portland Cement

This type of cement is made by increasing Al_2O_3 / Fe_2O_3 ratio. The normal dark color of Portland cement is due to ferrite phase and other components such as Mn_2O_3.

If the proportion of iron oxide in the cement is reduced to less than 4% the color of the cement becomes white.

Iron oxide present in cement raw mix. helps in improving the burning conditions of the cement clinker.

Also, Natural gas must be used instead of Mazzot in the manufacture process of clinker. This type of cement used for decorative work[(2)].

In addition to the types of Portland cement some other types are manufacture of which the "Blended Cement" as an important group.

This group contains Portland cement as one of their main components in addition to other natural or industrial by products. This group includes, slag, expanding and Pozzolanic cement. Blastfurance slag cement is composed of Portland cement clinker and granulated slag in proportions from 20 – 85 %[(2)].

I.2. Organic Concrete Admixture:

Nowadays concrete is being used for many purposes at different conditions, ordinary concrete may fail to exhibit the required quality. In such cases, admixture is added to make it more suitable for any required applications often, instead of using special cement; it is possible to change some of the