CHAPTER 1

1. INTRODUCTION

1.1. Introductory Remarks:

Cement is defined as material with adhesive and cohesive properties for binding fragments to a compact whole. Such a definition leads to a restriction of the designation of building materials binding with stones, bricks and building blocks in the constructional purposes and engineering works. In its broadest sense, the word cement denotes any kind of binding agent (**Hewlett, P.C., 1998**).

Cementing or binding properties of the paste are due to the chemical reactions between the cement and water. However, materials most commonly associated with this word are hydraulic cements of which Portland cement is the most familiar.

Hydraulic cements are the cements for making concrete which have the property of setting and hardening under water. Hydraulic cement when mixed with enough water to form a plastic mass (paste), the mixture starts to set, loses its plasticity and becomes hard, then develops strength. Most important properties of concrete such as strength, volume stability and permeability are mainly determined by the properties of the hardened cement paste.

The Portland cement is commercially produced by burning a mixture of calcareous and argillaceous raw materials in rotary kilns to a temperature of approximately 1300-1400°C. The fused product of the kiln is called clinker, this clinker is cooled and ground with a few percent of gypsum to give the desired retardation (**Taylor, H.F.W., 1972**).

The essential constituents of Portland cement clinker are lime, silica, alumina and iron oxide which are combined to form tricalcium silicate C_3S (alite), β-dicalcium silicate β-C_2S (belite), tricalcium aluminate C_3A (aluminate) and a ferrite phase; consisting of a solid solution of composition between C_2F and C_6A_2F, generally designated as C_4AF (tetracalium aluminoferrite).

The properties of Portland cement are mainly controlled by the relative properties of C_3S, β-C_2S, C_3A and C_4AF in the cement clinker. For instance, high early strength is derived from high C_3S. Low heat of hydration results from low content of C_3S and C_3A, and high resistance to sulphate attack is attributed to low content of C_3A (**Shondeep, L.S. and Harsh, S., 1993**).

Several types of Portland cement are manufactured having different characteristics. The classification of the various types of Portland cement is based on the rate of hydration, the rate and extent of heat of hydration as well as the resistance of the hardened cement paste against the attack by aggressive solutions. The characteristics of each type are influenced by the relative properties of the major phases, gypsum content, as well as the fineness of cement.

The most important standard types of Portland cement are (**Neville, A.M., 1981**).

i. Normal (ordinary) Portland cement (Types I):

This is general purpose cement, suitable for all uses when the special properties of other types are not required. The cooled clinker typically

contains four phases in the approximate proportions (**Neville, A.M., 1981**):

Tricalcium silicate	C_3S	55%
β-Dicalcium silicate	β-C_2S	25%
Tricalcium aluminate	C_3A	10%
Tetracalcium aluminateferrite	C_4AF	10%

The fineness even of the cement ranges between 2750 and 3250 cm^2/g.

ii. Modified Portland cement (Type II):

This type of cement is characterized by a lower heat of hydration and slightly slower rate of strength development than Type I. It has an improved resistance to sulphate attack and is used in structures of considerable size such as piers. According to the ASTM Standards, the C_3A content of this type of cement should not exceed 8% (**Neville, A.M., 1981**).

iii. High-early strength (rapid-hardening) Portland cement (Type III):

This cement is used when early strength is required. It sets and hardens much quicker than Type I., within a few minutes, but the ultimate strength is not higher. It is similar to Type I, but is normally ground to a higher fineness than Type I to develop early strength. Type I is ground to a surface area of 2750 to 3250 cm^2/g, compared with at least 3300-4000 cm^2/g.