Lecture 6

Types of cement

There are many types of cement such as:

- Natural cement
- Portland cement
- Expanding cement
- Aluminous cement
- Super – sulphate resistance cement

However, one of the most usable types is Portland cement. Thus, in this section we will focus on this type. As per ASTM, cement is designated as Type I, Type II, Type III, Type IV, Type V and other minor types like Type IS, Type IP and Type IA IIA and IIIA.

Type I: For use in general concrete construction where the special properties specified for Types II, III, IV and V are not required (Ordinary Portland Cement).

Type II: For use in general concrete construction exposed to moderate sulphate action, or where moderate heat of hydration is required.

Type III: For use when high early strength is required (Rapid Hardening Cement).

Type IV: For use when low heat of hydration is required (Low Heat Cement).

Type V: For use when high sulphate resistance is required (Sulphate Resisting Cement).

Type IS: This consists of an intimate and uniform blend of Portland cement of type I and fine granulated slag. The slag content is between 25 and 70 per cent of the weight of Portland Blast-Furnace Slag Cement.

Type IP: This consists of an intimate and uniform blend of Portland Cement (or Portland Blast Furnace Slag Cement) and fine pozzolana in which the pozzolana content is between 15 and 40 per cent of the weight of the total cement.

Type IA, IIA and IIIA

These are type I, II or III cement in which air-entraining agent is interground where air entrainment in concrete is desired.

What is the difference between aerated concrete and air entrained concrete?

Ordinary Portland cement (OPC): is by far the most important type of cement. The OPC was classified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days. Generally use of high grade cements offer many advantages for making stronger concrete. The ASTM standard limits the quantity of lime in this type to avoid the expansion:

$$L.S.F = \frac{(SO_3)\,0.7 \quad - (CaO)}{(Fe_2O_3)\,0.65 + (Al_2O_3)\,1.2 + (SiO_2)\,2.8}$$

L.S.F = (0.66 -1.02)

Rapid Hardening cement (RHC): This cement is similar to ordinary Portland cement. As the name indicates it develops strength rapidly and as such it may be more appropriate to call it as high early strength cement. It is pointed out that rapid hardening cement which develops higher rate of development of strength should not be confused with quick-setting cement which only sets quickly. Rapid hardening cement develops at the age of three days, the same strength as that is expected of ordinary Portland cement at seven days. The rapid rate of development of strength is attributed to the higher fineness of grinding (specific surface not less than 325 m^2/kg) and higher C3S and lower C2S content. A higher fineness of cement particles expose greater surface area for action of water and also higher proportion of C3S results in quicker hydration.

The rapid hardening cement should not be used in mass concrete construction why?. The use of rapid heading cement is recommended in the following situations:

(a) In pre-cast concrete construction.

(b) Where formwork is required to be removed early for re-use elsewhere,

(c) Road and airports repair works,

(d) In cold weather concrete where the rapid rate of development of strength reduces the vulnerability of concrete to the frost damage.

There is a special type named Extra RHC where its fineness reaches to700 m^2/kg.

Sulphate Resisting Cement (SRC): To reduce the sulphate attack, the use of cement with low C3A content is found to be effective why?. Such cement with low C3A and comparatively low C4AF content is known as Sulphate Resisting Cement. In other words, this cement has high silicate content. The specification generally limits the C3A content to 5%.

In many of its physical properties, sulphate resisting cement is similar to ordinary Portland cement. The use of sulphate resisting cement is recommended under the following conditions:

(a) Concrete to be used in marine condition;

(b) Concrete to be used in foundation and basement, where soil is infected with sulphates;

(c) Concrete used for fabrication of pipes which are likely to be submerged sulphate bearing soils;

(d) Concrete to be used in the construction of sewage treatment works.

Low heat cement (LHC): It is well known that hydration of cement is an exothermic action which produces large quantity of heat during hydration. Formation of cracks in large body of concrete due to heat of hydration has focussed the attention of the concrete technologists to produce a kind of cement which produces less heat or the same amount of heat, at a low rate during the hydration process. A low-heat evolution is achieved by reducing the contents of C3S and C3A which are the compounds evolving the maximum heat of hydration and increasing C2S. The feature of low-heat cement is a slow rate of gain of strength. But the ultimate strength of low-heat cement is the same as that of ordinary Portland cement.

The specific surface of low heat cement as found out by air-permeability method is not less than $320 m^2/kg$. The 7 days strength of low heat cement is not less than 16 MPa in contrast to 22 MPa in the case of ordinary Portland cement. Other properties, such as setting time and soundness are same as that of ordinary Portland cement.

Portland Slag Cement IS: Portland slag cement (PSC) is obtained by mixing Portland cement clinker, gypsum and granulated blast furnace slag in suitable proportions and grinding the mixture to get a thorough and intimate mixture between the constituents. The quantity of granulated slag mixed with Portland clinker will range from 25-65 %. In different countries this cement is known in different names. The quantity of slag mixed also will vary from country to country the maximum being up to 85 %. The major advantages of this type currently recognized are:

(a) Reduced heat of hydration;

(b) Refinement of pore structure;

(c) Reduced permeability;

(d) Increased resistance to chemical attack.

Portland Pozzolana Cement (IS): Portland Pozzolana cement (PPC) is manufactured by the intergrading of OPC clinker with 10 to 25 per cent of pozzolanic material (as per the latest amendment, it is 15 to 35%). A pozzolanic material is essentially a silicious or aluminous material which while in itself possessing no cementitious properties, which will, in finely divided form and in the presence of water, react with calcium hydroxide, liberated in the hydration process, at ordinary temperature, to form compounds possessing cementitious properties.

$$\text{Calcium hydroxide} + \text{Pozzolana} + \text{water} \rightarrow C - S - H \text{ (gel)}$$

Advantages of PPC:

(a) In PPC, costly clinker is replaced by cheaper pozzolanic material - Hence economical.

(b) Soluble calcium hydroxide is converted into insoluble cementitious products resulting in improvement of permeability. Hence it offers, durability characteristics, particularly in hydraulic structures and marine construction.

(c) PPC consumes calcium hydroxide and does not produce calcium hydroxide as much as that of OPC.

(d) It generates reduced heat of hydration and that too at a low rate.

(e) PPC being finer than OPC and also due to pozzolanic action, it improves the pore size distribution and also reduces the microcracks at the transition zone.

(f) Reduction in permeability of PPC offers many other alround advantages.

(g) As the fly ash is finer and of lower density, the bulk volume of 50 kg bag is slightly more than OPC. Therefore, PPC gives more volume of mortar than OPC.

(h) The long term strength of PPC beyond a couple of months is higher than OPC if enough moisture is available for continued pozzolanic action.

- Try to differentiate between the above types!
- Is there a possibility to invent new types of cement? How and why? Discuss with your colleges/tutor