Republic Of Iraq

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Building and Construction Tech. Eng. Dep.

Concrete Technology

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2017-2018

Soundness of cement

1- Free lime CaO

If the raw materials fed into the kiln contain more lime that can combine with the acidic oxides, or if burning or cooling are unsatisfactory, the excess lime will remain in a free condition. This hard-burnt lime hydrates only very slowly and, because slaked lime occupies a larger volume than the original free calcium oxide, expansion takes place. Cements which exhibit this expansion are described as unsound.

$CaO + H_2O \rightarrow Ca(OH)_2$

2- Free MgO

Cement can also be unsound due to the presence of MgO, which reacts with water in a manner similar to CaO. However, only periclase, that is, 'dead-burnt' crystalline MgO, is deleteriously reactive, and MgO present in glass is harmless, because it hydrates quickly transforming to the stable state in the hardened paste.

$MgO + H_2O \rightarrow Mg(OH)_2$

Up to about 2 per cent of periclase, (by mass of cement) combines with the main cement compounds, but excess periclase generally causes expansion and can lead to slow disruption.

3- Calcium sulfates (gypsum)

Gypsum added to the clinker during its grinding in order to prevent flash set, but if gypsum is present in excess of the amount that can react with C_3A during setting, unsoundness is in the form of a slow expansion will result.

Fineness of cement

Because hydration starts at the surface of the cement particles, it is the total surface area of cement. Thus, the rate of hydration depends on the fineness of the cement particles.

The high fineness is necessary for:

- Rapid development of strength, as shown in the figure below;

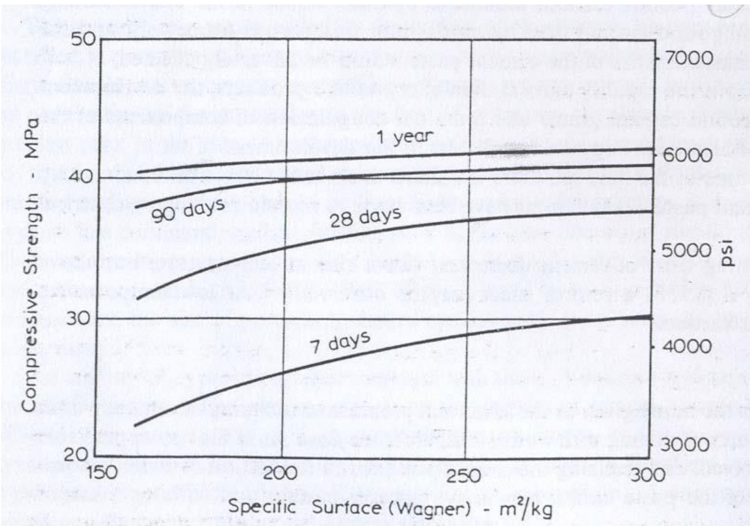

Figure (2): Relation between strength of concrete at different ages and fineness of coment.

- To cover surfaces of the fine aggregate particles at better manner – leading to better adhesion and cohesion between cement mortar constituents.

- To improve the workability of the concrete mix, but it will increase the amount of water required for the standard consistency.

- To reduce the water layer that separate on the mixture surface due to bleeding, as shown in the figure below.

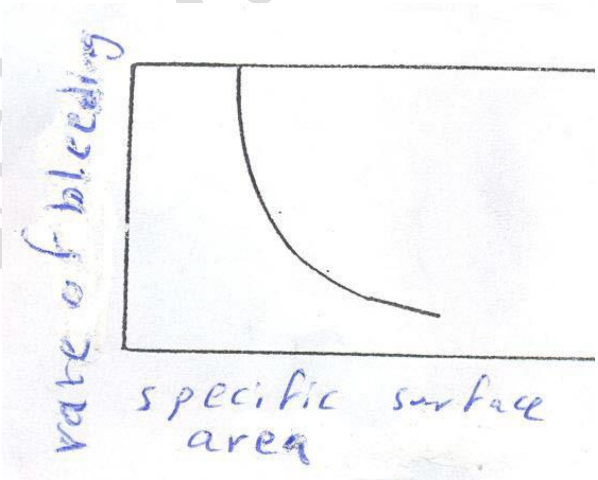

Figure (3): The relation between the rates of bleeding with specific surface area.

The disadvantage of high fineness, include:

- The cost of grinding to a higher fineness is considerable.

- The finer the cement the more rapidly it deteriorates on exposure to the atmosphere during bad storage.

- Finer cement increases the surface area of its alkalis – leads to stronger reaction with alkalireactive aggregate – cracks and deterioration of concrete.
- An increase in fineness increases the amount of gypsum required for proper retardation because, in finer cement, more C_3A is available for early hydration (due to the increase of its surface area).

<u>Heat of hydration of cement</u>

The quantity of evolved heat when the cement hydrated completely at a given temperature – Joule/gram or calorie/gram of unhydrated cement.

The hydration of cement compounds - accompanied with heat evolution, energy of up to 120 cal/g of cement being liberated.

<u>The actual value of the heat of hydration depends on:</u>

1- The chemical composition of the cement

Heat of hydration of cement = sum of the heats of hydration of the individual compounds when hydrated separately.

The contribution of individual compounds to the total heat of hydration of cement can be measured from the following equation:

Heat of hydration of 1 g of cement =

$136(C_3S) +62(C_2S) + 200(C_3A+) 30(C_4AF)$

Proportions of the compounds that hydrate most rapidly (C_3A and C_3S) the high rate of heat evolution in the early life of concrete can be lowered.

2- **Ambient temperature –** has great effect on the rate of heat evolution – The rate of heat evolution increase with increase in the ambient temperature.

3- **Type of cement**

Types of cement can be arranged in descending order with respect to their rate of heat evolution, as follows:

- Rapid hardening Portland cement.
- Ordinary Portland cement.
- Modified Portland cement.
- Sulfate resistant Portland cement.

- Low heat Portland cement.

4- **Fineness of cement**

An increase in fineness speed up the reactions of hydration and therefore the heat evolved.

5- **Amount of cement in the mixture**

The quantity of cement in the mix also affects the total heat development.

Influence of the compound composition on properties of cement

Main compounds

C_3S and C_2S – are the most important compounds – responsible for strength.

C_3S – contributes most to the strength development during the first four weeks.

C_2S – influences the gain in strength from 4 weeks onwards.

C_3A contributes to the strength of the cement paste at one to three days, and possibly longer.

The role of **C_4AF** in the development of strength of cement is not clear till now.

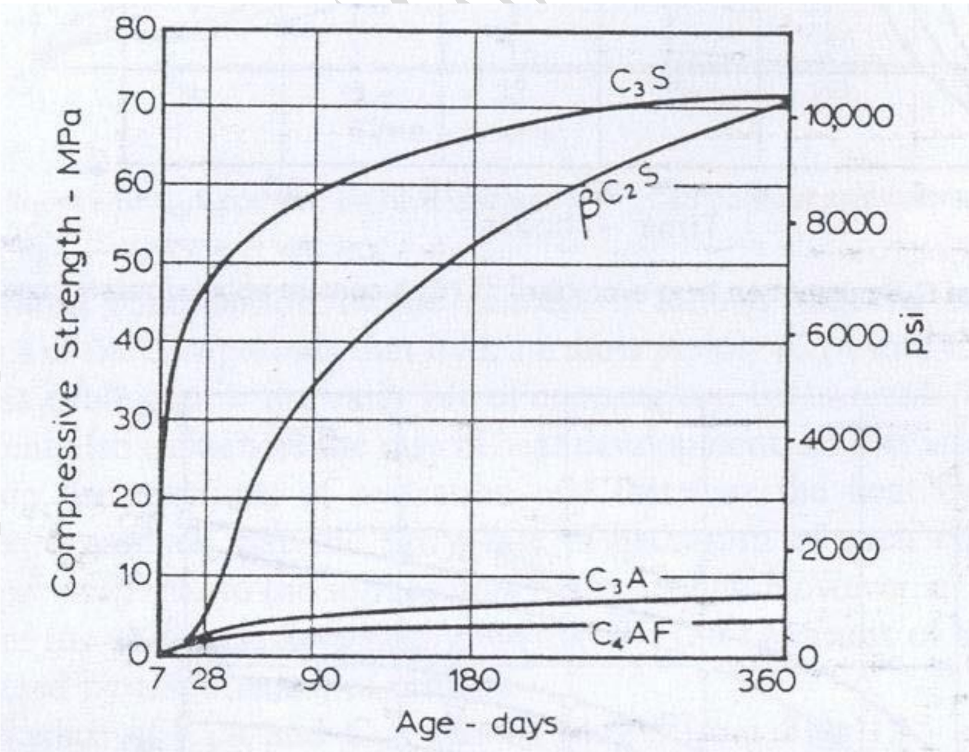

Figure (4): Development of strength of pure compounds according to Bogue.