Tests of cement:

Specifications for cement place limits on both its physical properties and chemical composition.

Cement should be tested in accordance with Iraqi Standard Specification (No. 5) at 1984. The followings are the main properties of cement and methods for testing these properties:

1- Setting

Setting refers to a change from a fluid to a rigid stage

Cement + water —cement paste —lose its plasticity gradually— when it loses its plasticity completely— setting occurs. The stages of setting include:

- Initial setting
- Final setting

It is important to distinguish setting from hardening**,** which refers to the gain of strength of a set cement paste. The two first to react are C_3A and C_3S.

The setting time of cement decreases with a rise in temperature.

The importance of setting in concrete works comes from the importance to keep the fresh concrete in the plastic stage for enough time necessary to complete its mixing and placing under practical conditions.

Vicat apparatus - use to measure the setting time for cement paste.

Initial setting time - refers to the beginning of the cement paste setting.

Final setting time - refers to the beginning of hardening and gain of strength.

Iraqi Standard Specification No. 5 limits:

- Initial setting time not less than 45 minutes.
- Final setting time not more than 10 hours.

Flash setting

If inadequate amounts of gypsum are added to the cement, flash set can occur--a rapid development of rigidity in freshly mixed portland cement paste, mortar, or concrete, usually with the evolution of considerable heat. This rigidity cannot be dispelled, nor can the plasticity be regained, by further mixing without addition of water.

The reaction of C_3A with water is very rapid and the presence of gypsum is retarding this reaction. The flash – setting properties of C_3A is delayed by the addition of gypsum (which delays the formation of calcium Aluminate hydrate) thus C_3S sets first.

False Setting:

False setting is the name given to the abnormal stiffening of cement within a few minutes of mixing with water. It differs from ***flash set*** in that no appreciable heat is evolved, and remixing the cement paste without addition of water restores plasticity of the paste until it sets in the normal manner and without a loss of strength.

False set occurs because some of the gypsum dehydrates as a result of contacting hot clinker or high temperatures in the grinding mill. This creates plaster that rehydrates to form gypsum and stiffen the concrete.

2- **Soundness of cement**

The cement considers unsound if it undergoes a large change in volume (expansion) - that cause cracking of hardened cement paste when it is under condition of restraint.

The Causes of expansion

1- Free lime CaO

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

$CaO + H2O — Ca(OH)2$

2- **Free MgO**

Cement can also be unsound due to the presence of MgO, which reacts with water in a manner similar to CaO.

$MgO + H2O — Mg(OH)2$

Up to about 2 percent of Mgo (by mass of cement) combines with the main cement compounds, but excess Mgo 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 C3A during setting, unsoundness is in the form of a slow expansion will result.

Test of Soundness

Le Chatelier's accelerated test is used for detecting unsoundness of cement due to free lime only. Essentially, the test is as follows. Cement paste of standard consistency is stored in water for 24 hours. The expansion is determined after increasing the temperature and boiling for 1 hour, followed by cooling to the original temperature.

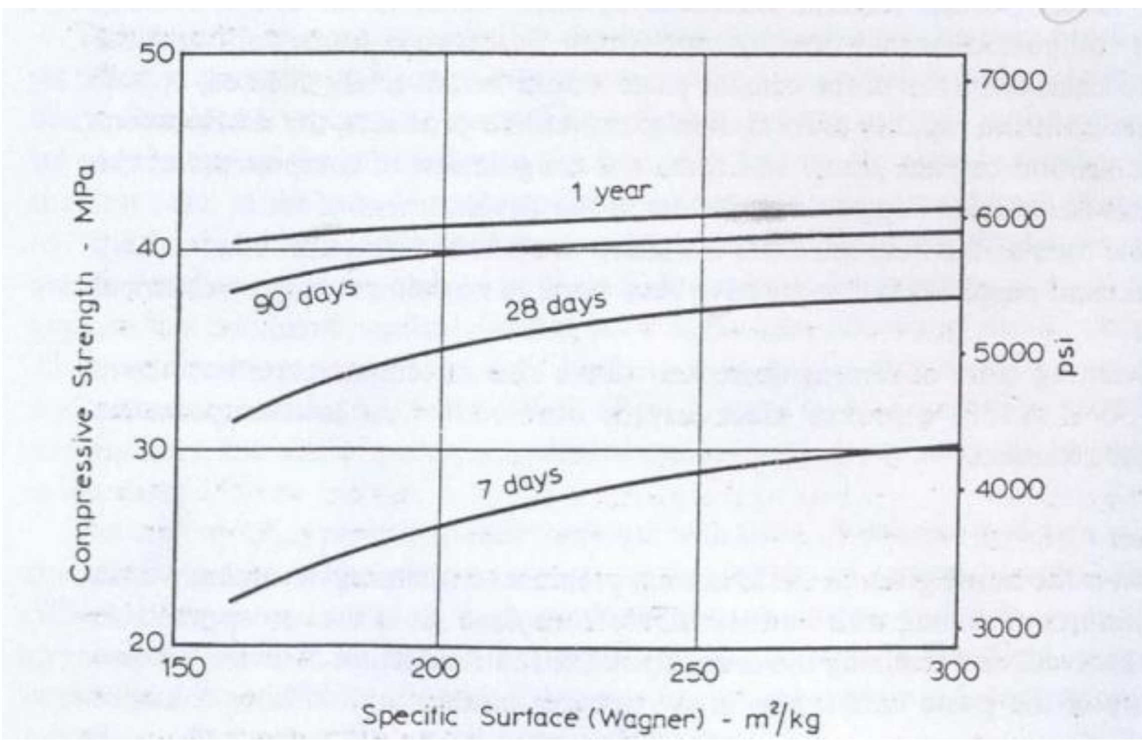
ASTM C 151 specifies the autoclave test which is sensitive to both free magnesia and free lime. Here, a neat cement paste specimen of known length is cured in humid air for 24 hours and then heated by high-pressure steam for about 1 hour so that a temperature of 216 °C is attained. After maintaining that temperature and pressure for a further 3 hours, the autoclave is cooled so that the pressure falls within 1.5 hours and the specimen is cooled in water to 23 °C in 15 min. After a further 15 min, the length of the specimen is measured: the expansion due to autoclaving must not exceed 0.8 per cent of the original length.

3- **Fineness of cement**

The last step in the manufacture of cement is the grinding of clinker mixed with gypsum.

Because hydration starts at the surface of the cement particles, it is the total surface area of cement that represents the material available for hydration. 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; although the long-term strength is not affected. A higher early rate of hydration means, also a higher rate of early heat evolution.



- 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.

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 alkali-reactive aggregate
- Cracks and deterioration of concrete.
- Finer cement exhibits a higher shrinkage and a greater proneness to cracking.
- An increase in fineness increases the amount of gypsum required for proper retardation because, in finer cement, more C3A is available for early hydration.

Tests of Fineness:

Fineness is a vital property of cement, and Iraqi **Standard (No. 5) at 1984** requires the determination of the specific surface in (m2/kg).

A direct approach is to measure the particle size distribution by sedimentation; these methods are based on Stoke's law, giving the terminal velocity of fall under gravity of a spherical particle in a fluid medium.

A development is the Wagner turbidi meter, as specified by ASTM C l15. Here, the concentration of particles in suspension at a given level in kerosene is determined using a beam of light, the percentage of light transmitted (and hence the area of particles) being measured by a photocell.

Blaine (ASTM C 204), method in which a volume of air at a prescribed pressure pass through a sample of cement, the rate of flow diminishing steadily; the time taken for the flow to take place is measured, and for a given apparatus and standard porosity, the specific surface can be calculated.

Dry sieving as per IS:12269 the residue of 100g cement sample on the 90µm IS sieve after sieving, it should not exceed following percentage by weight for different types of cement.

I) Ordinary Portland cement = 10%

II) Rapid hardening cement = 5%

III) Low heat cement = 5%