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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

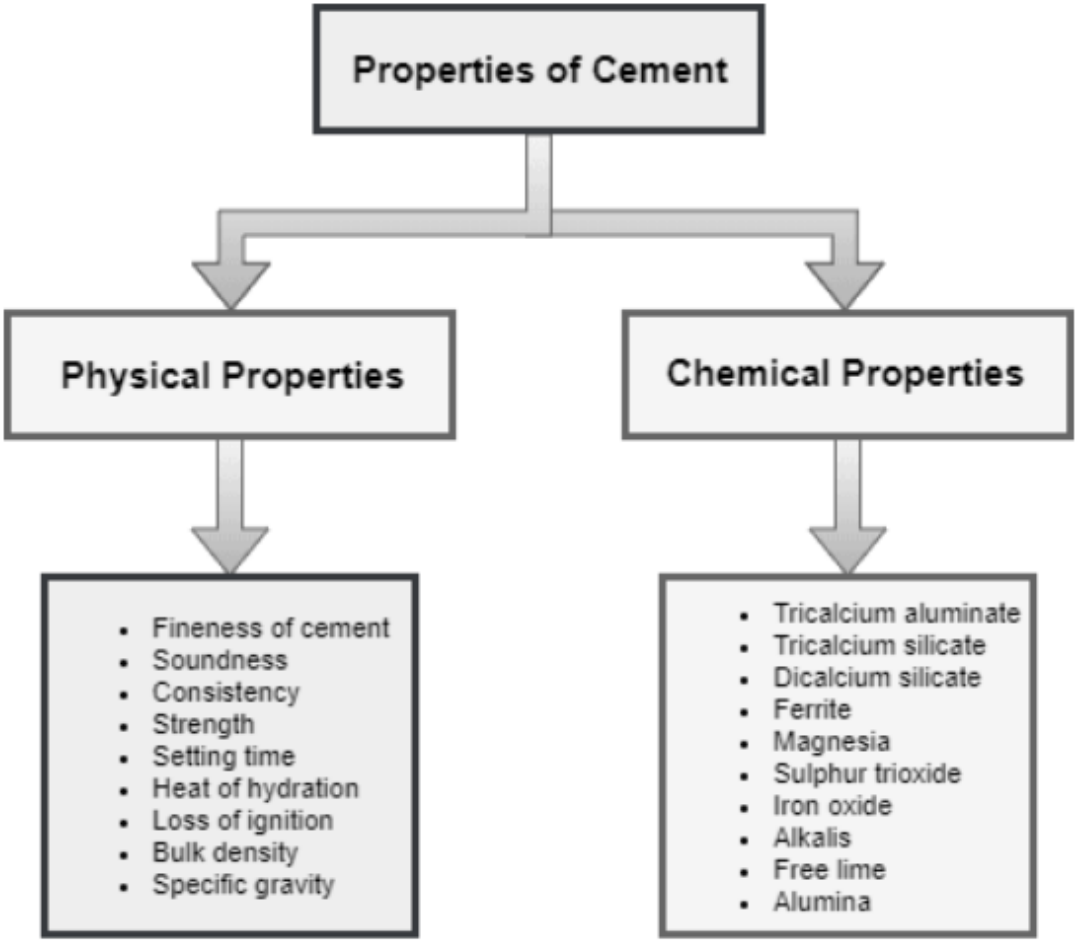
23GET102 – BASIC CIVIL AND MECHANICAL ENGINEERING

I YEAR / I SEMESTER

Unit 1 : Civil Engineering Materials and Surveying

Topic 3 : Properties of Cement

Properties of Cement



Fineness of Cement

- The size of the particles of the cement is its fineness.
- The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process.
- As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

Soundness of Cement

- Soundness refers to the ability of cement to not shrink upon hardening.
- Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.
- The unsoundness of cement is caused by the undesirable expansion of some of its constituents, sometimes after setting.
- The large change in volume accompanying expansion results in disintegration and severe cracking. the unsoundness is due to the presence of free lime and magnesia in the cement.

Soundness of Cement

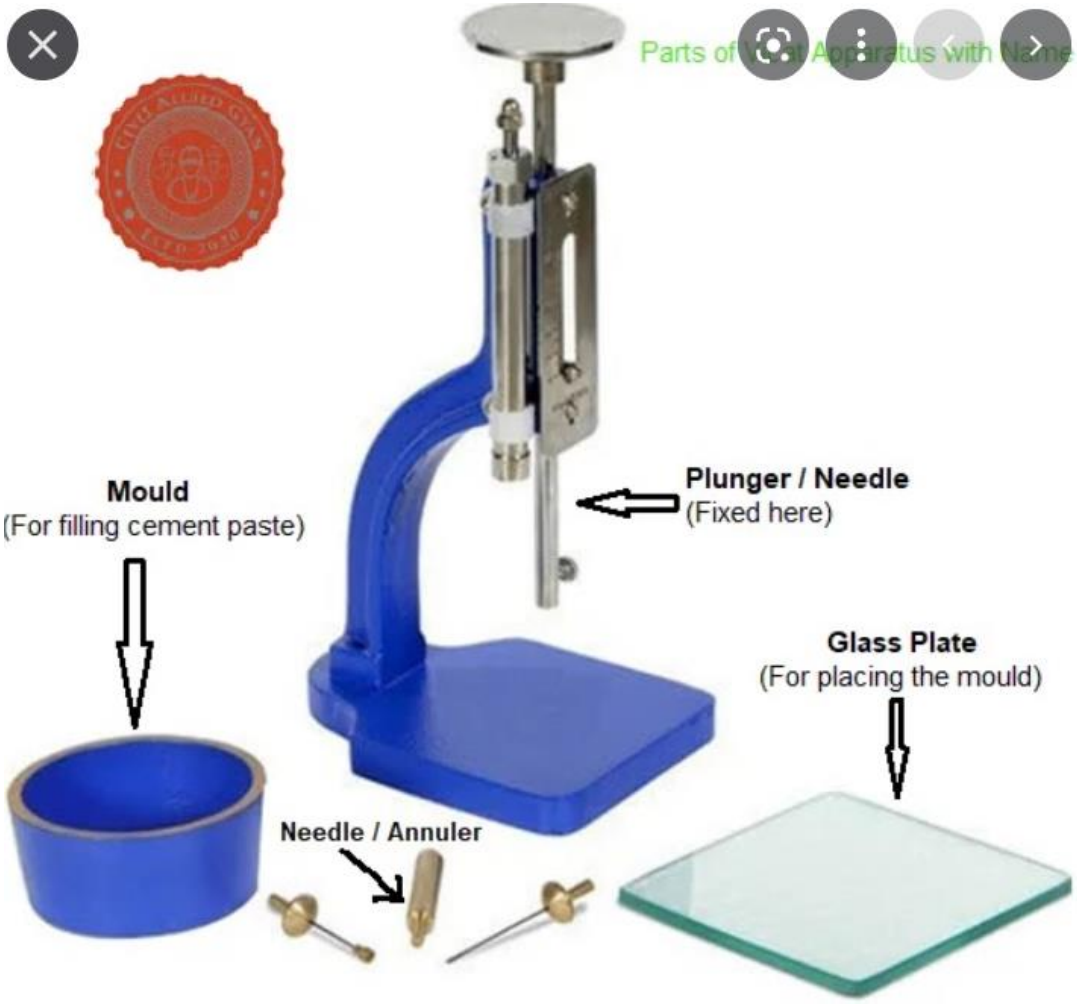
The unsoundness may reduce by

- Limiting the MgO content to less than 0.5%.
- Fine griding.
- Allowing the cement to aerate for several days.
- Thorough mixing.

Consistency of Cement

- The physical state of cement paste is called consistency.
- The purpose of the consistency test is to estimate the quantity of mixing water to form a paste of normal consistency.
- It is measured by the Vicat apparatus Test.
- If the water content in the cement paste is such that the Vicat's plunger penetrates up to 5 to 7 mm from the bottom of the mould, the cement paste is called to be of normal consistency.

Consistency of Cement



Strength of Cement

- Three types of strength of cement are measured – compressive, tensile and flexural.
- Various factors affect the strength, such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age.
- While testing the strength, the following should be considered:
  - Cement strength is merely a quality control measure.
  - Cement gains strength over time, so the specific time of performing the test should be mentioned.

Setting Time of Cement

- Cement sets and hardens when water is added.
- This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures.
- Cement used in construction should have an initial setting time that is not too low and a final setting time not too high.
- Hence, two setting times are measured:
  - **Initial set:** When the paste begins to stiffen noticeably (typically occurs within 30-45 minutes)
  - **Final set:** When the cement hardens, being able to sustain some load (occurs below 10 hours)
  - Again, setting time can also be an indicator of hydration rate.

Heat of Hydration

- When water is added to cement, the reaction that takes place is called hydration.
- Hydration generates heat, which can affect the quality of the cement and also be beneficial in maintaining curing temperature during cold weather.
- On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress.
- The heat of hydration is affected most by C_3S and C_3A present in cement, and also by water-cement ratio, fineness and curing temperature.
- The heat of hydration of Portland cement is calculated by determining the difference between the dry and the partially hydrated cement (obtained by comparing these at 7th and 28th days).

Loss of Ignition

- Heating a cement sample at 900 - 1000°C (that is, until a constant weight is obtained) causes weight loss.
- This loss of weight upon heating is calculated as loss of ignition.
- Improper and prolonged storage or adulteration during transport or transfer may lead to pre-hydration and carbonation, both of which might be indicated by increased loss of ignition.

Bulk Density

- When cement is mixed with water, the water replaces areas where there would normally be air.
- Because of that, the bulk density of cement is not very important.
- Cement has a varying range of density depending on the cement composition percentage.
- The density of cement may be anywhere from 62 to 78 pounds per cubic foot.

Specific Gravity

- Specific gravity is generally used in mixture proportioning calculations.
- Portland cement has a specific gravity of 3.15, but other types of cement (for example, Portland-blast-furnace-slag and Portland-Pozzolan cement) may have specific gravities of about 2.90.

Chemical Properties of Cement

- The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate.
- Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

Chemical Properties of Cement

Tricalcium aluminate (C3A)

- Low content of C3A makes the cement sulfate-resistant.
- Gypsum reduces the hydration of C_3A, which liberates a lot of heat in the early stages of hydration.
- C3A does not provide any more than a little amount of strength.
- Type I cement: contains up to 3.5% SO_3 (in cement having more than 8% C_3A)
- Type II cement: contains up to 3% SO_3 (in cement having less than 8% C_3A)

Chemical Properties of Cement

Tricalcium silicate (C_3S)

- C3S causes rapid hydration as well as hardening and is responsible for the cement's early strength gain an initial setting.

Dicalcium silicate (C_2S)

- As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helps the strength gain after one week.

Ferrite (C_4AF)

- Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F.
- Though it hydrates rapidly, it does not contribute much to the strength of the cement.

Chemical Properties of Cement

Magnesia (MgO)

- The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants.
- An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement.
- Production of MgO-based cement also causes less CO2 emission.
- All cement is limited to a content of 6% MgO.

Sulphur trioxide

- Sulfur trioxide in excess amount can make cement unsound.

Iron oxide/ Ferric oxide

- Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

Chemical Properties of Cement

Alkalis

- The amounts of potassium oxide (K_2O) and sodium oxide (Na_2O) determine the alkali content of the cement.
- Cement containing large amounts of alkali can cause some difficulty in regulating the setting time of cement.
- Low alkali cement, when used with calcium chloride in concrete, can cause discoloration.
- In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis.
- There is an optional limit in total alkali content of 0.60%, calculated by the equation $Na_2O + 0.658\ K_2O$.

Free lime

- Free lime, which is sometimes present in cement, may cause expansion.

Chemical Properties of Cement

Silica fumes

- Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength.
- Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength.
- Hence, Portland cement containing 5-20% silica fume is usually produced for Portland cement projects that require high strength.

Alumina

- Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical-resistant.
- It also quickens the setting but weakens the cement.

Properties of Cement Mortar

- It should be easily workable.
- It should develop adequate strength in tension, compression, and bond for the work.
- It should be durable.
- It should not affect the durability of other materials.
- It should be set quickly so that the speed of construction is ensured.
- It should be cheaply available.
- It should bind the bricks or stones to give a tight joint through which water cannot penetrate.
- The joints form by mortar should not develop cracks and they should be able to maintain their appearance for quite a long time.

Thank You!!