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DEPARTMENT OF CIVIL ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

Topics to be covered:

- Concrete Making Materials
- Aggregates, Its Properties and Testing
- Cement, Its Properties and Testing

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CONCRETE MAKING MATERIALS :

- Concrete is one of the most versatile and widely produced construction materials in the world (Penttala, 1997).
- Its worldwide annual production exceeds 12 billion metric tons, i.e., more than two metric tons of concrete was produced each year for every person on earth in 2007.
- The ever-increasing population, living standards, and economic development lead to an increasing demand for infrastructure development and hence concrete materials.
- As a composite material, concrete is composed of different graded aggregates or fillers embedded in a hardened matrix of cementitious material.
- The properties of major constituents of concrete mixtures, such as aggregates, cementitious materials, admixtures, and water, should be understood first to better learn the properties and performance of concrete.
- Concrete is a hardened building material created by combining a chemically inert mineral aggregate (usually sand, gravel, or crushed stone), a binder (natural or synthetic cement), chemical additives, and water. Although people commonly use the word "cement" as a synonym for concrete, the terms in fact denote different substances: cement, which encompasses a wide variety of fine-ground powders that harden when mixed with water, represents only one of several components in modern concrete.
- As concrete dries, it acquires a stone-like consistency that renders it ideal for constructing roads, bridges, water supply and sewage systems, factories, airports, railroads, waterways, mass transit systems, and other structures that comprise a substantial portion of the wealth of the nation.
- The words cement and concrete are both of Latin origin, reflecting the likelihood that the ancient Romans were the first to use the substances.
- Structural concrete normally contains one part cement to two parts fine mineral aggregate to four parts coarse mineral aggregate, though these proportions are often varied to achieve the strength and flexibility required in a particular setting.
- In addition, concrete contains a wide range of chemicals that imbue it with the characteristics desired for specific applications.

AGGREGATES :

- Aggregates constitute a skeleton of concrete.
- Approximately three-quarters of the volume of conventional concrete is occupied by aggregate.
- It is inevitable that a constituent occupying such a large percentage of the mass should contribute important properties to both the fresh and hardened product.
- Aggregate is usually viewed as an inert dispersion in the cement paste. However, strictly speaking, aggregate is not truly inert because physical, thermal, and, sometimes, chemical properties can influence the performance of concrete.

EFFECTS OF AGGREGATES

(A) AGGREGATE IN FRESH AND PLASTIC CONCRETE: When concrete is freshly mixed, the aggregates are suspended in the cement–water–air bubble paste. The behavior of fresh concrete, such as fluidity, cohesiveness, and rheological behavior, is largely influenced by the amount, type, surface texture, and size gradation of the aggregate. The selection of aggregate has to meet the requirement of the end use, i.e., what type of structure to be built.

(B) AGGREGATE IN HARDENED CONCRETE: Although there is little chemical reaction between the aggregate and cement paste, the aggregate contributes many qualities to the hardened concrete. In addition to reducing the cost, aggregate in concrete can reduce the shrinkage and creep of cement paste. Moreover, aggregates have a big influence on stiffness, unit weight, strength, thermal properties, bond, and wear resistance of concrete.

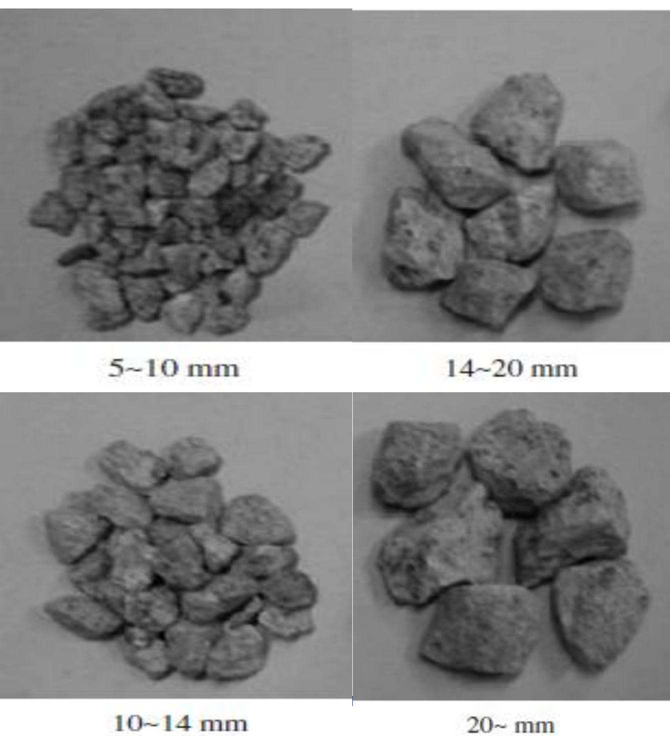
CLASSIFICATION OF AGGREGATES : Aggregates can be divided into several categories according to different criteria, such as size, Source, and unit weight.

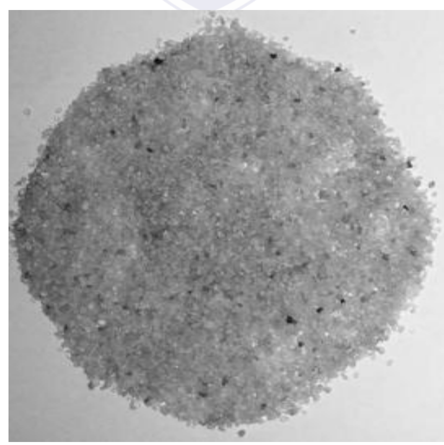
AGGREGATES

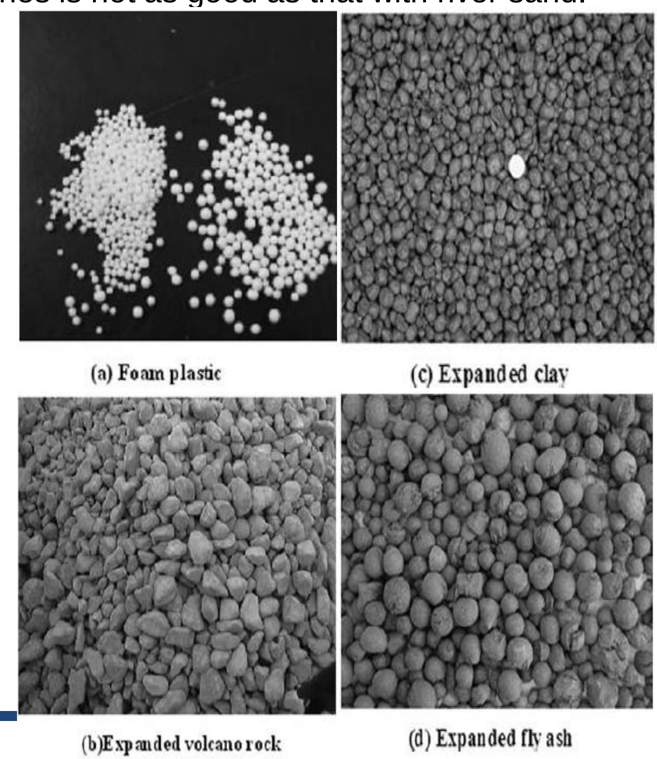
IN ACCORDANCE WITH SIZE :

COARSE AGGREGATE: Aggregates predominately retained on a No. 4 (4.75-mm) sieve are classified as coarse aggregate. Generally, the size of coarse aggregate ranges from 5 to 150 mm. For normal concrete used for structural members such as beams and columns, the maximum size of coarse aggregate is about 25 mm. For mass concrete used for dams or deep foundations, the maximum size can be as large as 150 mm.

FINE AGGREGATE (SAND): Aggregates passing through a No. 4 (4.75 mm) sieve and predominately retained on a No. 200 (75 µm) sieve are classified as fine aggregate. River sand is the most commonly used fine aggregate. In addition, crushed rock fines can be used as fine aggregate. However, the finish of concrete with crushed rock fines is not as good as that with river sand.







AGGREGATES :

IN ACCORDANCE WITH SOURCE :

NATURAL AGGREGATES: This kind of aggregate such as sand and gravel is taken from natural deposits without changing the nature during production.

MANUFACTURED (SYNTHETIC) AGGREGATES: These kinds of aggregate are manmade materials, resulting from products or by-products of industry. Some examples are blast furnace slag and lightweight aggregate.

IN ACCORDANCE WITH UNIT WEIGHT :

ULTRA-LIGHTWEIGHT AGGREGATE: The unit weight of such aggregates is less than 500 kg/m3, including expanded perlite and foam plastic. The concrete made of ultra-lightweight aggregates has a bulk density from 800 to 1100 kg/m3, depending on the volume fraction of aggregate. Such a concrete can be used only as nonstructural members, like partition walls.

LIGHTWEIGHT AGGREGATE: The unit weight of such aggregates is between 500 and 1120 kg/m3. Examples of lightweight aggregates include cinder, blast-furnace slag, volcanic pumice, and expanded clay. The concrete made of lightweight aggregate has a bulk density between 1200 and 1800 kg/m3. Such concrete can be either a structural member or nonstructural member, depending what type of aggregate is used.

NORMAL-WEIGHT AGGREGATE: An aggregate with a unit weight of 1520–1680 kg/m3 is classified as normal-weight aggregate. Sand, gravel, and crushed rock belong to this category and are most widely used. Concrete made with this type of aggregate has a bulk density of 2300–2400 kg/m3. It is the main concrete used to produce important structural members.

HEAVY-WEIGHT AGGREGATE: If the unit weight of aggregate is greater than 2100 kg/m3, it is classified as heavy-weight aggregate. Materials used as heavy-weight aggregate are iron ore, crashed steel pieces, and magnetite limonite. The bulk density of the corresponding concrete is greater than 3200 kg/m3 and can reach 4000 kg/m3. This kind of concrete has special usage, like radiation shields in nuclear power plants, hospitals, and laboratories. It can also be used as sound-shielding material.

PROPERTIES OF AGGREGATES :

MOISTURE CONDITIONS : The moisture condition defines the presence and amount of water in the pores and on the surface of the aggregate. There are four moisture conditions as :

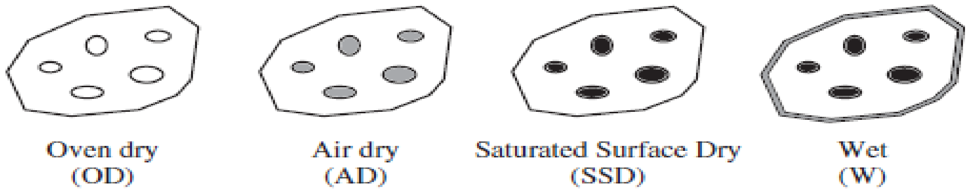
(A) OVEN DRY (OD): This condition is obtained by keeping the aggregate in an oven at a temperature of 110◦C long enough to drive all water out from internal pores and hence reach a constant weight.

(B) AIR DRY (AD): This condition is obtained by keeping the aggregate at ambient temperature and ambient humidity. Under such condition, pores inside of aggregate are partly filled with water. When aggregate is under either the OD or AD condition, it will absorb water during the concrete mixing process until the internal pores are fully filled with water.

(C) SATURATED SURFACE DRY (SSD): In this situation, the pores of the aggregate are fully filled with water and the surface is dry. This condition can be obtained by immersing coarse aggregate in water for 24 h followed by drying of the surface with a wet cloth. When the aggregate is under the SSD condition, it will neither absorb water nor give out water during the mixing process. Hence, it is a balanced condition and is used as the standard index for concrete mix design.

(D) WET (W): The pores of the aggregate are fully filled with water and the surface of the aggregate has a film of water. When aggregate is in a wet condition, it will give out water to the concrete mix during the mixing process. Since sand is usually obtained from a river, it is usually in a wet condition.

It should be noted that in designing a concrete mix, the moisture content usually uses the SSD condition as a reference, because it is an equilibrium condition at which the aggregate will neither absorb water nor give up water to the paste.



PROPERTIES OF AGGREGATES :

DENSITY AND SPECIFIC GRAVITY :

Since aggregates are porous materials, even a single piece of aggregate contains both solid material volume and pores volume. Hence, two types of aggregate density are defined.

Density (D) is defined as the weight per unit volume of solid material only, excluding the pores volume inside a single aggregate:

$$D = \frac{\text{weight}}{V_{\text{solid}}}$$

Bulk density (BD) is defined as the weight per unit volume of both solid material and the pores volume inside a single aggregate:

$$\text{BD} = \frac{\text{weight}}{V_{\text{solid}} + V_{\text{pores}}}$$

SPECIFIC GRAVITY (SG) :

Specific gravity (SG) is a ratio of density or bulk density of aggregate to density of water. Or SG is the mass of a given substance per unit mass of an equal volume of water. Depending on the definition of volume, the specific gravity can be divided into absolute specific gravity (ASG) and bulk specific gravity (BSG).

$$\text{ASG} = \frac{\dfrac{\text{weight of aggregate}}{V_{\text{solid}}}}{\text{density of water}} = \frac{D}{\rho_{\text{w}}} \qquad \text{BSG} = \frac{\dfrac{\text{weight of aggregate}}{V_{\text{solid}} + V_{\text{pores}}}}{\text{density of water}} = \frac{\text{BD}}{\rho_{\text{w}}}$$

UNIT WEIGHT (UW) : The unit weight is defined as the weight per unit bulk volume for bulk aggregates. In addition to the pores inside each single aggregate, the bulk volume also includes the space among the particles. According to the weight measured at different conditions, the unit weight can be divided into UW(SSD) and UW(OD):

$$\text{UW (SSD)} = \frac{W_{\text{SSD}}}{V_{\text{solid}} + V_{\text{pores}} + V_{\text{spacing}}} \qquad \text{UW (OD)} = \frac{W_{\text{OD}}}{V_{\text{solid}} + V_{\text{pores}} + V_{\text{spacing}}}$$

PROPERTIES OF AGGREGATES :

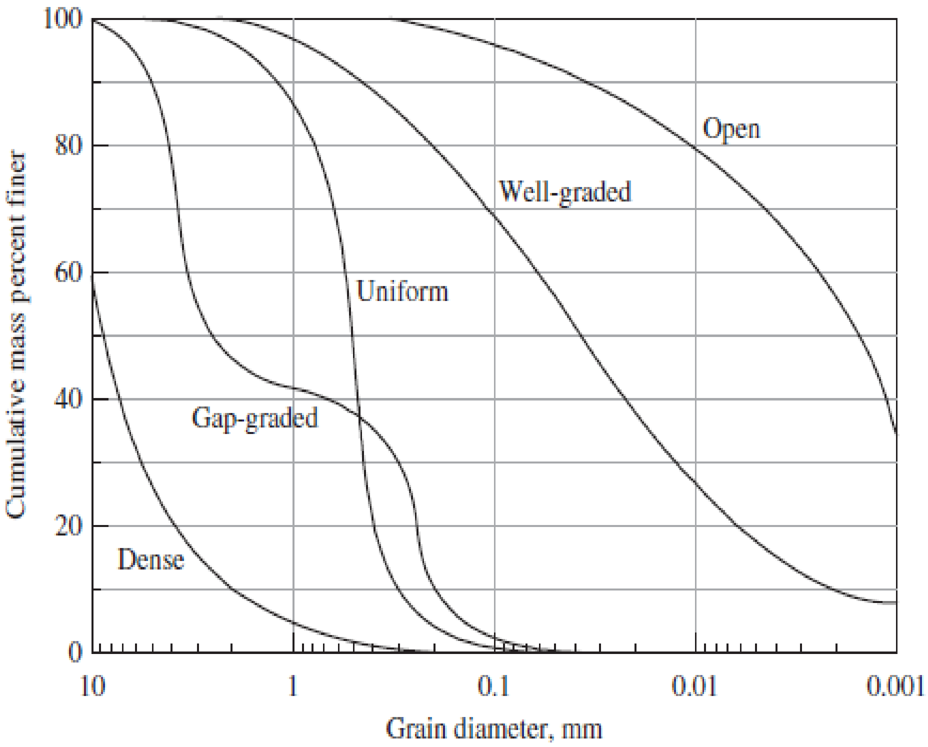
GRADING AGGREGATES : GRADING AND SIZE DISTRIBUTION : The particle size distribution of aggregates is called grading. Grading determines the paste requirement for a workable concrete since the amount of voids among aggregate particles requires the same amount of cement paste to fill out in the concrete mixture. To obtain a grading curve for an aggregate, sieve analysis has to be conducted.

- **Five size distributions are generally recognized: Dense, Gap graded, Well-graded, Uniform graded, and Open graded.**
- The dense and well-graded types are essentially the wide size ranges with smooth distribution.
- They are the desired grading for making concrete.
- The dense graded is for coarse aggregate and well-graded for fine aggregate.
- Gap grading is a kind of grading that lacks one or more intermediate size; hence, a nearly flat horizontal region appears in the grading curve.
- For uniform grading, only a few sizes dominate the bulk materials, and the grading curve falls almost vertically at the dominating size.
- Open grading is defined as being under compact conditions, the voids among the aggregate are still relatively large.
- In open grading, usually the smaller size of aggregate dominates the bulk and can be easily disturbed by a small cavity.
- Open-grade material is not suitable to be used for sub-grade construction of a road.

FINENESS MODULUS : To characterize the overall coarseness or fineness of an aggregate, the concept of a fineness modulus is developed. The fineness modulus is defined as :

$$\text{fineness modulus} = \frac{\sum (\text{cummulative retained percentage})}{100}$$

PROPERTIES OF AGGREGATES :



FIVE TYPES OF AGGREGATE GRADATION

Sieve Designation	Nominal Size of Sieve Opening
3 in.	75 mm
1.5 in.	37.5 mm
3/4 in.	19 mm
3/8 in.	9.5 mm
No. 4	4.75 mm
No. 8	2.36 mm
No. 16	1.18 mm
No. 30	600 µm
No. 50	300 µm
No. 100	150 µm
No. 200	75 µm

COMMON SIEVE DESIGNATION & CORRESPONDING SIEVE SIZE

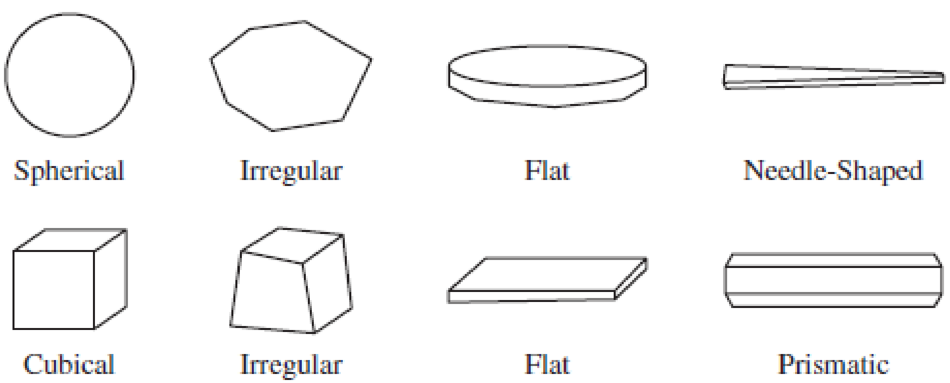
It can be seen from the formula that calculation of the fineness modulus requires that the sum of the cumulative percentages retained on a definitely specified set of sieves be determined, and the result divided by 100. The sieves specified to be used in determining the fineness modulus are No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, 3/8”, 3/4”, 1.5”, 3”, and 6”. It can be seen that the size of the opening in the above sieves has a common factor of 0.5 in any two adjacent ones. They are called full-size sieves. Any sieve size between full-size sieves is called half-size.

PROPERTIES OF AGGREGATES :

SHAPE AND TEXTURE OF AGGREGATES :

SHAPE OF AGGREGATES : The aggregate shape affects the workability of concrete due to the differences in surface area caused by different shapes. Sufficient paste is required to coat the aggregate to provide lubrication. Among these, spherical, cubical, and irregular shapes are good for application in concrete because they can benefit the strength. Flat, needle-shaped, and prismatic aggregates are weak in load-carrying ability and easily broken. Besides, the surface-to-volume ratio of a spherical aggregate is the smallest.

TEXTURE OF AGGREGATES : The surface texture of aggregates can be classified in 6 groups: glassy, smooth, granular, rough, crystalline, and honeycombed. The surface texture of aggregates has significant influence on the fluidity of fresh concrete and the bond between aggregate and cement paste of hardened concrete.



DIFFERENT BASIC SHAPES OF AGGREGATES

	Relative Effect (%) of	
Affected Strength	**Shape**	**Surface Texture**
Compressive	22	44
Flexural	31	26

EFFECTS OF AGGREGATE SHAPE AND SURFACE TEXTURE ON CONCRETE STRENGTH

CEMENT, ITS PROPERTIES AND TESTING :

Cement, in general, adhesive substances of all kinds, but, in a narrower sense, the binding materials used in building and civil engineering construction. Cements of this kind are finely ground powders that, when mixed with water, set to a hard mass. Setting and hardening result from hydration, which is a chemical combination of the cement compounds with water that yields submicroscopic crystals or a gel-like material with a high surface area. Because of their hydrating properties, constructional cements, which will even set and harden under water, are often called hydraulic cements. The most important of these is Portland cement.

CEMENT, ITS PROPERTIES AND TESTING :

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most-consumed resource. Portland cement is made up of four main compounds:

1) Tri-calcium silicate (3CaO · SiO2),
2) Di-calcium silicate (2CaO · SiO2),
3) Tri-calcium aluminates (3CaO · Al2O3),
4) Tetra-calcium alumino-ferrite (4CaO · Al2O3Fe2O3).

In an abbreviated notation differing from the normal atomic symbols, these compounds are designated as C3S, C2S, C3A, and C4AF, where C stands for calcium oxide (lime), S for silica, A for alumina, and F for iron oxide.

Small amounts of uncombined lime and magnesia also are present, along with alkalis and minor amounts of other elements.

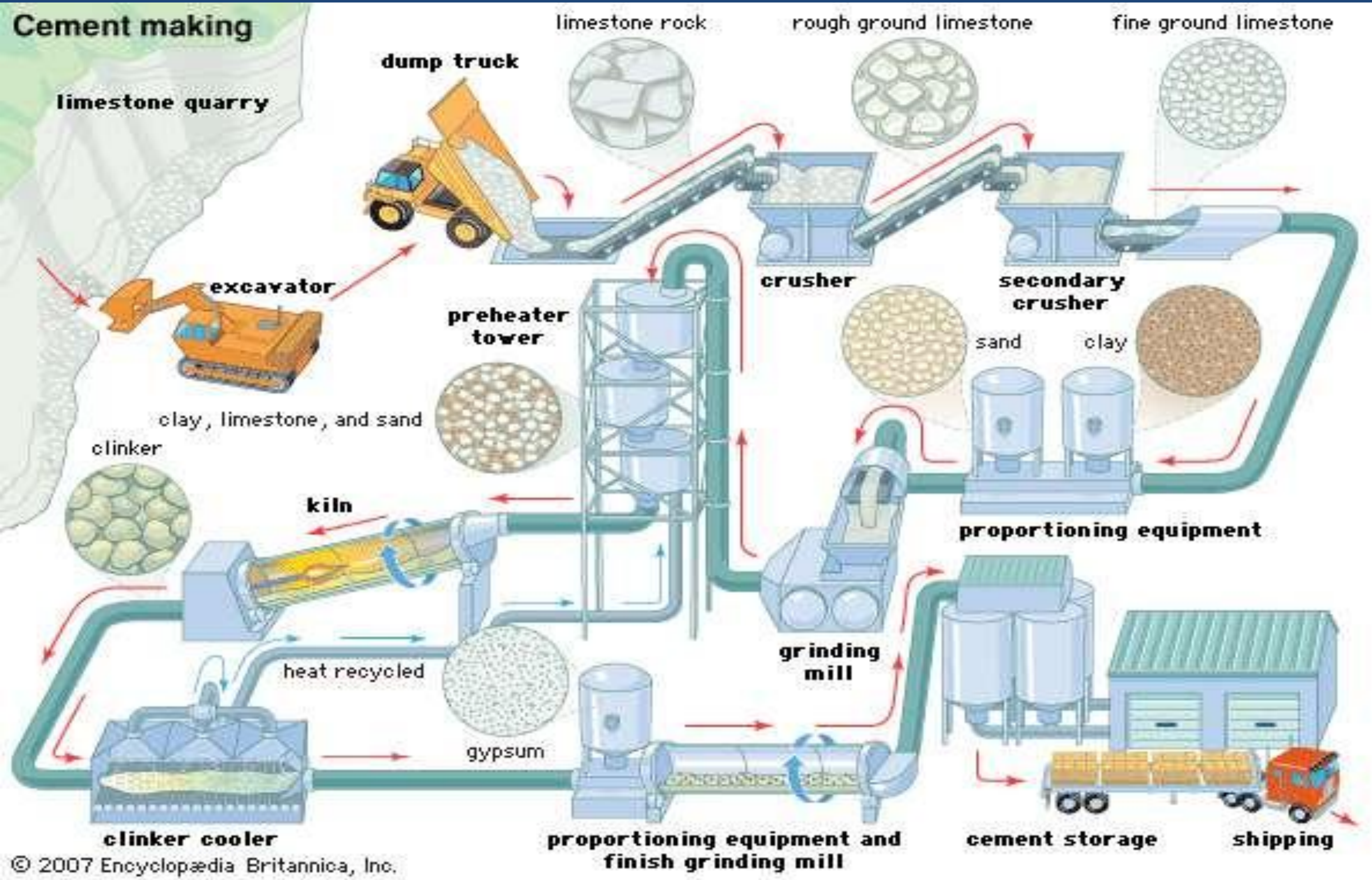
HYDRATION : The most important hydraulic constituents are the calcium silicates, C_2S and C_3S. Upon mixing with water, the calcium silicates react with water molecules to form calcium silicate hydrate ($3CaO \cdot 2SiO_2 \cdot 3H_2O$) and calcium hydroxide ($Ca[OH]_2$). These compounds are given the shorthand notations C–S–H (represented by the average formula $C_3S_2H_3$) and CH, and the hydration reaction can be crudely represented by the following reactions:

$2C_3S + 6H = C_3S_2H_3 + 3CH$

$2C_2S + 4H = C_3S_2H_3 + CH$

During the initial stage of hydration, the parent compounds dissolve, and the dissolution of their chemical bonds generates a significant amount of heat. Then, for reasons that are not fully understood, hydration comes to a stop. This quiescent, or dormant, period is extremely important in the placement of concrete. Without a dormant period there would be no cement trucks; pouring would have to be done immediately upon mixing.

CEMENT, ITS PROPERTIES AND TESTING :



CEMENT, ITS PROPERTIES AND TESTING :

PHYSICAL PROPERTIES OF CEMENT : Different blends of cement used in construction are characterized by their physical properties. Some key parameters control the quality of cement. The physical properties of good cement are based on:

1) Fineness of cement
2) Soundness
3) Consistency
4) Strength
5) Setting time
6) Heat of hydration
7) Loss of ignition
8) Bulk density
9) Specific gravity (Relative density)

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.

CEMENT, ITS PROPERTIES AND TESTING :

TESTS: Unsoundness of cement may appear after several years, so tests for ensuring soundness must be able to determine that potential.

LE CHATELIER TEST : This method, done by using Le Chatelier Apparatus, tests the expansion of cement due to lime. Cement paste (normal consistency) is taken between glass slides and submerged in water for 24 hours at 20+1°C. It is taken out to measure the distance between the indicators and then returned under water, brought to boil in 25-30 minutes and boiled for an hour. After cooling the device, the distance between indicator points is measured again. In a good quality cement, the distance should not exceed 10 mm.

AUTOCLAVE TEST : Cement paste (of normal consistency) is placed in an autoclave (high-pressure steam vessel) and slowly brought to 2.03 MPa, and then kept there for 3 hours. The change in length of the specimen (after gradually bringing the autoclave to room temperature and pressure) is measured and expressed in percentage. The requirement for good quality cement is a maximum of 0.80% autoclave expansion.

CONSISTENCY OF CEMENT : The ability of cement paste to flow is consistency. It is measured by Vicat Test. In Vicat Test Cement paste of normal consistency is taken in the Vicat Apparatus. The plunger of the apparatus is brought down to touch the top surface of the cement. The plunger will penetrate the cement up to a certain depth depending on the consistency. A cement is said to have a normal consistency when the plunger penetrates 10±1 mm.

CEMENT, ITS PROPERTIES AND TESTING :

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 mortar strength and cement concrete strength are not directly related. Cement strength is merely a quality control measure. The tests of strength are performed on cement mortar mix, not on cement paste. Cement gains strength over time, so the specific time of performing the test should be mentioned.

COMPRESSIVE STRENGTH : It is the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The loading sequence must be within 20 seconds and 80 seconds.

TENSILE STRENGTH : Though this test used to be common during the early years of cement production, now it does not offer any useful information about the properties of cement.

FLEXURAL STRENGTH : This is actually a measure of tensile strength in bending. The test is performed in a 40 x40 x 160 mm cement mortar beam, which is loaded at its center point until failure.

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.

CEMENT, ITS PROPERTIES AND TESTING :

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 (RELATIVE DENSITY) : 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-Pozzolana cement) may have specific gravities of about 2.90.

CEMENT, ITS PROPERTIES AND TESTING :

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.

TRI-CALCIUM ALUMINATE (C_3A) : 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)

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 tri-calcium silicate, which helps early strength gain, di-calcium silicate in cement helps the strength gain after one week.

TETRA CALCIUM ALUMINO 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.

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.

CEMENT, ITS PROPERTIES AND TESTING :

ALKALIES : 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.

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.

CEMENT, ITS PROPERTIES AND TESTING :

Testing of cement can be brought under two categories:

(A) FIELD TESTING

(B) LABORATORY TESTING.

FIELD TESTING : It is sufficient to subject the cement to field tests when it is used for minor works. The following are the field tests:

a) Open the bag and take a good look at the cement. There should not be any visible lumps. The color of the cement should normally be greenish grey.
b) Thrust your hand into the cement bag. It must give you a cool feeling. There should not be any lump inside.
c) Take a pinch of cement and feel-between the fingers. It should give a smooth and not a gritty feeling.
d) Take a handful of cement and throw it on a bucket full of water, the particles should float for some time before they sink.
e) Take about 100 grams of cement and a small quantity of water and make a stiff paste. From the stiff paste, pat a cake with sharp edges. Put it on a glass plate and slowly take it under water in a bucket. See that the shape of the cake is not disturbed while taking it down to the bottom of the bucket. After 24 hours the cake should retain its original shape and at the same time it should also set and attain some strength.

If a sample of cement satisfies the above field tests it may be concluded that the cement is not bad. The above tests do not really indicate that the cement is really good for important works. For using cement in important and major works it is incumbent on the part of the user to test the cement in the laboratory to confirm the requirements of the Indian Standard specifications with respect to its physical and chemical properties. No doubt, such confirmations will have been done at the factory laboratory before the production comes out from the factory. But the cement may go bad during transportation and storage prior to its use in works.

CEMENT, ITS PROPERTIES AND TESTING :

The following tests are usually conducted in the laboratory:

(a) Fineness Test.
(b) Setting Time Test.
(c) Strength Test.
(d) Soundness Test.
(e) Heat of Hydration Test.
(f) Chemical Composition Test.

FINENESS TEST : The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength, The fineness of grinding has increased over the years. But now it has got nearly stabilized. Different cements are ground to different fineness. The disadvantages of fine grinding is that it is susceptible to air set and early deterioration.

By and large an average size of the cement particles may be taken as about 10 micron. The particle size fraction below 3 microns has been found to have the predominant effect on the strength at one day while 3-25 micron fraction has a major influence on the 28 days strength. Increase in fineness of cement is also found to increase the drying shrinkage of concrete. In commercial cement it is suggested that there should be about 25-30 per cent of particles of less than 7 micron in size.

Fineness of cement is tested in two ways :

(a) By sieving.

(b) By determination of specific surface (total surface area of all the particles in one gram of cement) by air-permeability apparatus. Expressed as cm2/gm or m2/kg. Generally Blaine Air-permeability apparatus is used.

SIEVE TEST : Weigh correctly 100 grams of cement and take it on a standard IS Sieve No. 9 (90 microns). Break down the air-set lumps in the sample with fingers. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes. Mechanical sieving devices may also be used. Weigh the residue left on the sieve. This weight shall not exceed 10% for ordinary cement. Sieve test is rarely used.

CEMENT, ITS PROPERTIES AND TESTING :

AIR PERMEABILITY METHOD : This method of test covers the procedure for determining the fineness of cement as represented by specific surface expressed as total surface area in sq. cm/gm. of cement. It is also expressed in m2/kg. Lea and Nurse Air Permeability Apparatus is shown in Fig. 2.6. This apparatus can be used for measuring the specific surface of cement. The principle is based on the relation between the flow of air through the cement bed and the surface area of the particles comprising the cement bed. From this the surface area per unit weight of the body material can be related to the permeability of a bed of a given porosity. The cement bed in the permeability cell is 1 cm. high and 2.5 cm. in diameter. Knowing the density of cement the weight required to make a cement bed of porosity of 0.475 can be calculated. This quantity of cement is placed in the permeability cell in a standard manner. Slowly pass on air through the cement bed at a constant velocity. Adjust the rate of air flow until the flow meter shows a difference in level of 30-50 cm. Read the difference in level (h1) of the manometer and the difference in level (h2) of the flow meter. Repeat these observations to ensure that steady conditions have been obtained as shown by a constant value of h1/h2. Specific surface Sw is calculated from the following formula: $S_w = K\sqrt{h_1 / h_2}$ and $K = \frac{14}{d\,(1-\xi)}\sqrt{\frac{\xi^3 A}{CL}}$

where, ξ= Porosity, i.e., 0.475

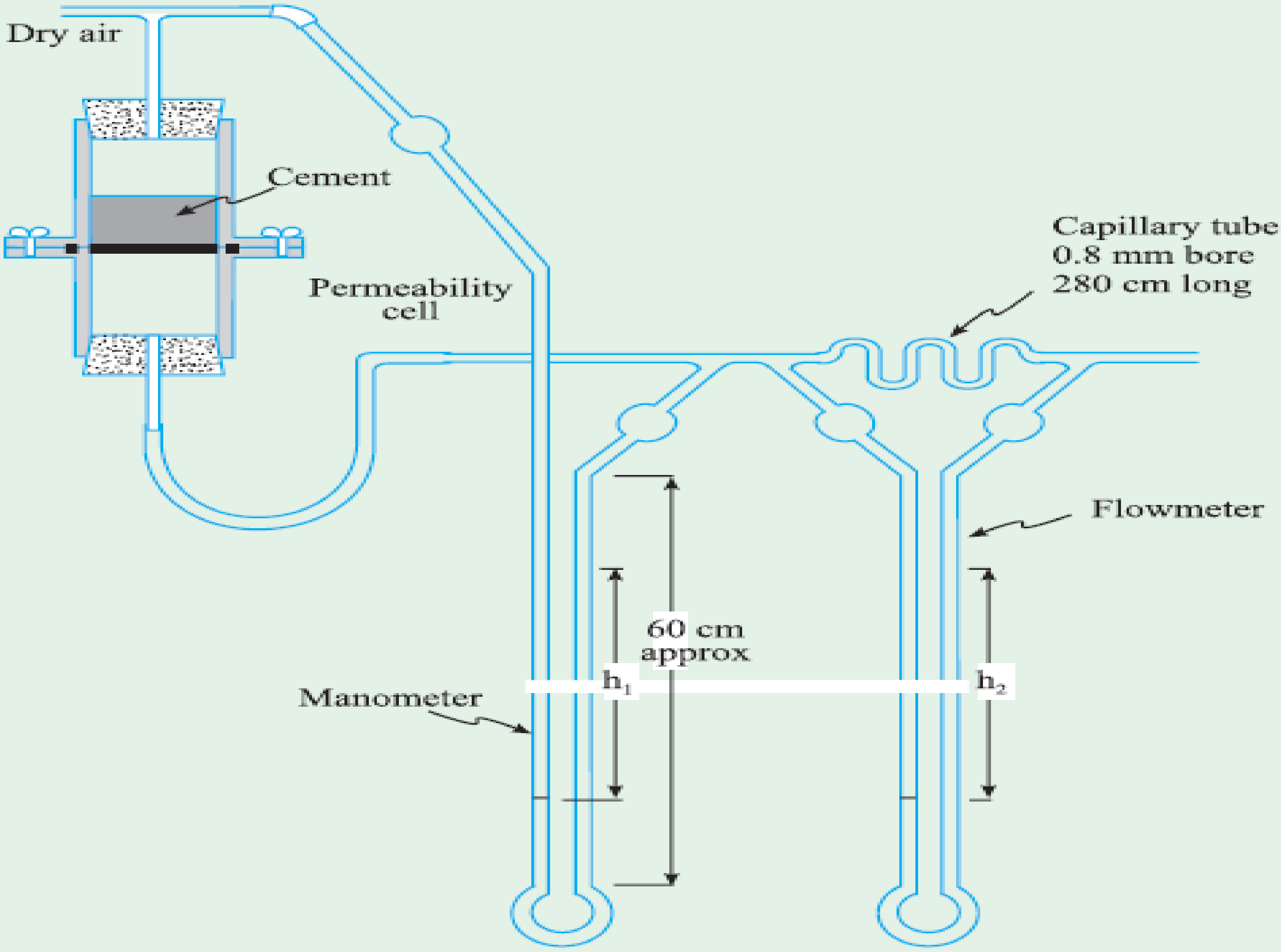
A = Area of the cement bed

L = Length (cm) of the cement bed

d = Density of cement, and

C = Flow meter constant

Fineness can also be measured by Blain Air Permeability apparatus. This method is more commonly employed in India.


Dry air
Cement
Permeability cell
Capillary tube
0.8 mm bore
280 cm long
Flowmeter
60 cm approx
h1
h2
Manometer

“Thank you”

Have Any Query ?

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