LAB WORK NO 10: DETERMINATION OF SETTING TIME OF PORTLAND CEMENT

DISCUSSION:

The initial set is a stage in the process of hardening after which any cracks that may appear will not reunite. The concrete is said to be finally set when it has attained sufficient strength and hardness.

REFERENCE:

ASTM C 191-71

AASHTO T 131-74

ESSENTIAL EQUIPMENT AND MATERIALS:

a. Portland Cement
b. Vicat Apparatus
c. Rubber Mold
d. Balance sensitive to 0.1 gm.
e. Mixing container
f. Graduated cylinder
g. Spatula

TESTING PROCEDURES:

a. Test for fineness of cement.
b. Weigh about 300 gms. of cement accurately and make a paste with 0.85 times the water required to make a paste of normal consistency.
c. The paste is then placed in the rubber mold.
d. The small end of the rod is brought in contact with the surface of the paste and quickly released.
e. The penetration of the needle can be read on the goals. The initial set is said to have occurred when the needle ceases to penetrate a point 5 mm above the bottom of the mold.
f. The time taken from the instant of adding water to the cement up to the moment when the needle ceases to penetrate a point 5 mm above the bottom of the mold is known as the initial setting time of the cement. For ordinary Portland cement, the initial setting time should not be less than 30 minutes.

DATA AND RESULTS:

A. Weight of cement: 300 gms

B. Volume of water: 82 ml

C. Water-Cement Ratio:

$$\frac{\text{Water in one cube yard of the mix (in lbs)}}{\text{Cement in the mix (in lbs)}}$$

*Volume of water= $82 \text{ ml x } \frac{0.00220462 \text{ lbs}}{1 \text{ ml}} = 0.18 \text{ lbs}$

*Weight of cement = $300 \text{ grams} \times \frac{0.00220462}{1 \text{ gram}} = 0.66 \text{ lbs}$

$$= \frac{0.18 \text{ lbs}}{0.66 \text{ lbs}}$$

= 0.27

D. Initial setting time: 2700

E. Final setting time:

TRIALS	TIME (minutes)	DEPTH OF PENETRATION (millimeter)
1	5	0
2	10	0
3	15	0
4	20	0
5	25	1
6	30	2
7	35	3
8	40	4
9	45	5

DISCUSSION OF THEORY:

The setting time of cement includes the initial setting time and the final setting time. The initial time refers to the time that cement turns into paste by mixing with water and begins to lose its plasticity. And the time that cement completely loses its plasticity by mixing with water and begins to have a certain structural strength is known as the final setting time. The national standards prescribe that the initial setting time of Portland cement should not be earlier than 45 min and the final setting time should not be later than 6.5 h. All the products off-grade at the initial setting time are spoiled products and those unqualified at the final setting time are sub-quality products.

The setting time of cement is measured by time determinator. The sample is the standard cement paste of which the temperature is 20 °C ± 3 °C and humidity is more than 90%. Various mineral components of the cement clinker are different in the water consumption of their normal consistency. The finer the cement is ground, the more water the normal consistency will need. The normal consistency of Portland cement is within 24% ~ 30%.

The setting time of cement is very important in the construction projects. The initial setting time should not be too fast in order to ensure that there is enough time to complete every process, such as casting, before the initial setting time; and the final setting time should not be too late in order to enable the cement to complete its setting and hardening as soon as possible after pouring and tamping to make the next process occur earlier. (Dhir, 2017)

The initial setting time of concrete is the time when cement paste starts hardening while the final setting time is the time when cement paste has hardened sufficiently in such a way that a 1 mm needle makes an impression on the paste in the mold but 5 mm needle does not make any impression.

Theoretically, Initial setting time of concrete is the time period between additions of water to cement till the time at 1 mm square section needle fails to penetrate the cement paste, placed in the Vicat's mold 5mm to 7mm from the bottom of the mold. Final setting time is that time period between the time water is added to cement and the time at which 1 mm needle makes an impression on the paste in the mold but 5 mm attachment does not make any impression.

Final setting time is the time when the paste completely loses its plasticity.It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mould in which it is cast. The determination of final setting time period facilitates safe removal of scaffolding or form. During this period of time primary chemical reaction of cement with water is almost completed.

Technical Aspects of Concrete Setting Times

1. It is essential that cement set neither too rapidly nor too slowly. In the first case there might be insufficient time to transport and place the concrete before it becomes too rigid. In the second case too long a setting period tends to slow up the work unduly, also it might postpone the actual use of the structure because of inadequate strength at the desired age.
2. Setting should not be confused with hardening, which refers to the gain in mechanical strength after the certain degree of resistance to the penetration of a special attachment pressed into it.
3. Setting time is the time required for stiffening of cement paste to a defined consistency.

4. Indirectly related to the initial chemical reaction of cement with water to form aluminum-silicate compound.
5. Initial setting time is the time when the paste starts losing its plasticity.
6. Initial setting time test is important for transportation, placing and compaction of cement concrete.
7. Initial setting time duration is required to delay the process of hydration or hardening.
8. Final setting time is the time when the paste completely loses its plasticity.
9. It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mold in which it is cast.
10. Determination of final setting time period facilitates safe removal of scaffolding or form.
11. During this period of time primary chemical reaction of cement with water is almost completed. (Rahman, 2019)

Setting time using Vicat test

The Vicat method consists in a penetration of a standard needle into a cement paste. According to the Standard Method NM 65:2003 (equivalent to ASTM C191-13), the initial time of setting occurs when the needle stops at 1mm from the bottom and the final set when the needle stops at 38mm (2 mm from the surface). Some researchers claim that this method has some disadvantages, and its accuracy of execution is dependent on the expertise of the technician responsible for testing [3,11].

The tests are carried out at an environmental temperature not considering any climatic condition, and as reported in literature, the values obtained are empirical, useful only as a comparative basis, not corresponding to specific aspects of microstructure formation during the initial hydration or about the rheological parameters of suspensions [3,9–10]. Besides that, with the needle penetration, the formed structure is gradually broken and, therefore, the obtained result is questionable, discontinuous and does not give any information about the beginning of cement hydration.

As the setting time is measured by the depth of needle penetration in function of time, according some authors [3,12], from the rheological point of view, the only force capable to stop the penetration is the paste yield stress. Therefore, while the applied force is greater than the yield stress, the penetration goes on, but from the moment when the generated yield stress becomes lower than that force, the penetration stops, indicating the final setting time.

However, the use of Vicat test is very simple and has as advantages the low cost and easiness to use for a standard specification control, despite of being applied just only as a comparative basis. In this work, it was applied in order to correlate their results with other techniques available. (Paulo, 2018)

REPORT:

1. Plot the semi-logarithmic scale a curve showing the relationship between time (abscissa) and the depth of penetration (ordinate). From this curve drawn, determine the time required for 25 mm needle penetration.

2. Explain the following:

a. The difference between hydraulic and non-hydraulic cement.

There are two main types of cement: hydraulic and non-hydraulic. Both are used to construct buildings, homes, sidewalks and bridges, and to make repairs on properties and structures. There are several differences between the two, including how they are made and how long it takes for them to harden. In fact, non-hydraulic cement is used less in today's fast-paced construction because of the time and conditions needed for it to finish strengthening.

Some of the differences between hydraulic and non-hydraulic cement lie in the materials used to make them and the ways that they are formed. Hydraulic cement is a mixture of limestone, clay and gypsum which are burned together under extreme temperatures. The material used to make non-hydraulic cement include lime, gypsum plasters and oxychloride.

Another difference between the two cements is the time it takes each to strengthen. Hydraulic cement starts to harden instantly and can be completed in as little as a few minutes if applied to small areas, or a few days for bigger projects. Non-hydraulic cement, on the other hand, takes longer to harden, which delays the completion of projects.

The major difference between hydraulic and non-hydraulic cement is the hardening process. Hydraulic cement can harden while in contact with water. Non-hydraulic cement needs dry conditions to strengthen. This is a major advantage for hydraulic cement, as construction projects using this type of cement are completed in various weather conditions.

b. Dry process of manufacturing Portland cement.

In this process, the raw materials dried and ground to a fine powder by grinding mill. The dry powder is then further blende and corrected for its right composition and mixed by means of compressed air. The blended powder then store in the storage silos from where. It is the pass to the granulator comprising an inclined rotating drum or dish.

A quantity of water about 12 percent by weight then add to make the blended powder into nodules. These nodules are then dry by preheater and then enter to the rotary kiln from the upper end. These nodules drop to lower end where it subject to the temperature about 1500oc Chemical reaction takes place and 20 to 30% material get the fuse. Lime silica and alumina get recombine. The fused mass turns into a nodular form called clinker.

The clinker drops into the rotary cooler, where it is cool under control conditions. The cool clinker is then ground in a ball mill with the addition of 2 to 3% of gypsum. In the ball mill, particles crush to a fine powder and filled into bags.

The equipment used in the dry process in comparatively smaller. This process is economical than the wet process. The total consumption of coal in the dry process is only about 100 kg, as compared to the requirement of about 350 kg, for producing a tons of cement in the wet process.

3. List eight types of Portland cement and give their uses.

a. **TYPE I**

Type I is a general purpose Portland cement suitable for all uses where the special properties of other types are not required. It is used where cement or concrete is not subject to specific exposures, such as sulfate attack from soil or water, or to an objectionable temperature rise due to heat generated by hydration. Its uses include pavements and sidewalks, reinforced concrete buildings, bridges, railway structures, tanks, reservoirs, culverts, sewers, water pipes and masonry units.

b. **TYPE II**

Type II Portland cement is used where precaution against moderate sulfate attack is important, as in drainage structures where sulfate concentrations in ground waters are higher than normal but not unusually severe (Table 2). Type II cement will usually generate less heat at a slower rate than Type I. With this moderate heat of hydration (an optional requirement), Type II cement can be used in structures of considerable mass, such as large piers, heavy abutments, and heavy retaining walls. Its use will reduce temperature rise -- especially important when the concrete is placed in warm weather.

c. **TYPE III**

Type III is a high-early strength Portland cement that provides high strengths at an early period, usually a week or less. It is used when forms are to be removed as soon as possible, or when the structure must be put into service quickly. In cold weather, its use permits a reduction in the controlled curing period. Although richer mixtures of Type I cement can be used to gain high early strength, Type III, high early-strength Portland cement, may provide it more satisfactorily and more economically.

d. **TYPE IA, IIA, IIIA**

Specifications for three types of air-entraining Portland cement (Types IA, IIA, and IIIA) are given in ASTM C 150. They correspond in composition to ASTM Types I, II, and III, respectively, except that small quantities of air-entraining materials are underground with the clinker during manufacture to produce minute, well distributed, and completely separated air bubbles. These cements produce concrete with improved resistance to freeze-thaw action.

e. **TYPE IV**

Type IV is a low heat of hydration cement for use where the rate and amount of heat generated must be minimized. It develops strength at a slower rate than Type I cement. Type IV Portland cement is intended for use in massive concrete structures, such as large gravity dams, where the temperature rise resulting from heat generated during curing is a critical factor.

f. **TYPE V**

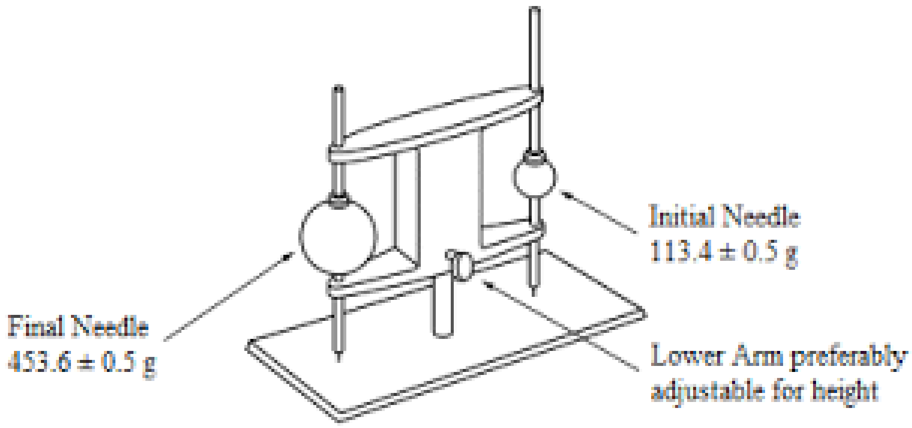
Type V is a sulfate-resisting cement used only in concrete exposed to severe sulfate action -- principally where soils or ground waters have a high sulfate content. Table 1 describes sulfate concentrations requiring the use of Type V Portland cement. Low Tricalcium Aluminate (C3A) content, generally 5% or less, is required when high sulfate resistance is needed.

4. Give and describe significant characteristics of Portland cement.

Portland cement is a complex product obtained from unprocessed common natural materials: limestone and clay. Consequently, the characteristics of Portland cement clinker may vary from one cement plant to another. To limit the variations of the technological properties of Portland cement, acceptance standards have been developed, but presently these standards are not satisfactory for the whole concrete market. Low which cements are increasingly used; these concretes are made using large dosage of super plasticizers to disperse cement particles. It is therefore urgent for the cement industry to produce a clinker that will facilitate the production of the low w/c concretes that are more sustainable than normal-strength concretes. The production of the old Type I/II clinker must continue to satisfy the needs of this very profitable market, because now that we know how to increase concrete compressive strength, it is very important that we focus on how to improve the rheology of these concretes in order to transform concrete into a quasi-liquid material that can be poured without any problem.

5. **Draw and describe the Gilmore apparatus**

Gillmore Needle Apparatus is used to determine initial and final set times of Portland cement, masonry cement, hydraulic hydrated lime, and certain mortars in accordance with ASTM C266 and other standards. The adjustable support has horizontal arms to guide two weighted needles with flat-end cylindrical stainless steel tips. The base has an ample flat shelf for positioning specimens. In testing the molded specimen for the time of setting, the initial-set needle is 1/4lb (113.4g) and 1/12in (2.12mm) diameter. Final-set needle is 1lb (453.6g) and 1/24in (1.06mm) diameter.



APPENDICES:

I. DETAILED COMPUTATIONS

II. REFERENCES:

Dhir, R. K., (2017). Initial Setting Time Retrieved from https://www.sciencedirect.com/topics/engineering/initial-setting-time#:~:text=The%20national%20standards%20prescribe%20that,be%20later%20than%206.5%20h.

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Paolo, S., (2018) Hardening phenomenon of Portland cement suspensions monitored by Vicat test, isothermal calorimetry and oscillatory rheometry Retrieved from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1983-41952018000500949

III. ASTM/AASHTO Standards (will be provided)