



Faculty of Engineering and Technology

Civil Engineering Department

Construction Materials Laboratory

ENCE215

Experiment # 7

“ Consistency of standard cement paste, Mortar test and Setting time tests ”

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## - Introduction

### **Background information**

The process of manufacturing concrete is originated by the occurrence of a chemical reaction called ' The hydration reaction of cement '. This hydration reaction begins when water is added to cement, where certain chemical compounds in cement form the gel paste that solidifies with time. The process by which the cement paste transforms from its flowable state to the rigid state is called ' Setting '. Cement paste sets at two main stages, the first is called the ' initial setting ' which indicates that the paste has noticeably stiffened and can not be remolded. The second is called the ' final setting ' which is labeled when the cement paste has hardened to an extent that enables it to resist some load.

Experimentally, the setting times could be measured using the Vicat apparatus. The initial setting time is defined to be the time measured from the instance of adding water to cement until the 1 mm diameter Vicat needle penetrates 5 to 7 mm from the bottom of the Vicat mold. Whereas the final setting time is defined by the required time for the other Vicat needle ( that has a circular attachment ) to leave only a point impression without the circular impression, also measured from the instance of adding water.

A number of tests carried out on Cement, including the setting time of cement and other tests, require that the cement paste possesses a standard consistency. The standard consistency of a cement paste is defined as the percentage of water added to 300 gm cement required to obtain a 5 to 7 mm needle penetration measured from the bottom of the mold using the Vicat apparatus. It should be pointed that this test is considered sensitive to the surrounding circumstances at which the test was

performed. The most common controlling factors are the temperature and the way of compacting the paste into the mold.

Another usual test related to cement is the ' Mortar test ', this test is usually performed by measuring the compressive strength ( could be tensile or flexural ) of cubes made only out of cement and sand. It is very important to realize that the strength obtained by the mortar test doesn't resemble the strength of concrete made by the same cement, thus the mortar test is often used as a quality control test of the cement properties. There are lots of agents that might influence the strength measurements in this test, such as the water to cement ratio, the gradation of sand, the method of compaction inside molds, size and shape of specimen and many other factors as well.

### **Purpose**

The targets of this experiment are:

- a) to find the optimum water content required to achieve the standard consistency of cement paste.
- b) To measure the initial and final setting times of a standard cement paste.
- c) To make a quality control check on cement, by finding the compressive strength of mortar cubes.

### **- Hypotheses**

The ( ASTM ) specifications prescribe an initial setting time that ranges from 2 to 4 hours, and a final setting time range from 5 to 8 hours. Hence, it is predicted that measurements lie within these ranges. Also, one expects that the measured strength of the mortar cubes should be less than the concrete cubes

since most of the concrete strength comes from the coarse aggregate. From previous experience working with concrete, it is predicted that the strength of the mortar cubes would increase as they age.

Formulas:

$$\text{a) } \sigma = \frac{P}{A}$$

Where:

$\sigma$ : the strength.

P: the failure load.

A: the cross-sectional area.

$$\text{b) } \rho = \frac{W_{SSD}}{W_{SSD} - W_{sub}}$$

Where:

$\rho$ : the density.

$W_{SSD}$ : the saturated surface dry weight.

$W_{Sub}$ : the submerged weight.

- **Procedure**

a) Consistency of standard cement paste:

- 1) 300 gm of cement were weighed, and put on a tray, and an opening ( a well ) in the middle of the dry cement was made.
- 2) Starting at a water percentage of ( 37% ) 111 gm of water were poured in the cement well.
- 3) The stopwatch was turned on simultaneously with the addition of water.
- 4) Using the trowel the cement and water were thoroughly mixed for 4 minutes.
- 5) The mix was put inside the Vicat mold.
- 6) The 1 mm diameter Vicat needle was adjusted so as to just touch the surface of the paste and then it was locked.
- 7) The needle was released to fall under the influence of its own weight and penetrate the paste.
- 8) The previous steps were repeated by 1% decrements of water until the needle penetrated the paste 5 to 7 mm from the bottom of the mold ( which turned out to be 34.5% ) .

b) The setting time of cement:

- 1) The same procedure of the standard consistency were followed to produce a cement paste but this time with 34.5% water, ( the optimum water content obtained from the consistency test ).
- 2) After an hour and a half, the Vicat apparatus were used to find the penetration of the mold.

- 3) The paste was checked using the Vicat tools every hour, until 5 to 7 mm penetration from bottom was obtained, at this point the initial setting time was recorded.
- 4) Then the paste was checked every hour using the other needle with the circular attachment.
- 5) When the impression left on the surface of the paste was only a point, and the circular attachment failed to leave an impression, the time was recorded as the final setting time.

c) Mortar test:

- 1) The fines were sieved ( according to the standards but we didn't ).
- 2) Then 523 gm of sand, 180 gm of cement and 90 gm of water were weighed.
- 3) The cement and sand were mixed dry for one minute.
- 4) The water was added to the dry mix and the stopwatch was on.
- 5) The components were mixed for 2 minutes.
- 6) The molds were attached to the mold vibrator one by one.
- 7) The mix was poured into each one of the three lubricated 7\*7\*7 cm cubes.
- 8) Compaction was performed using mechanical vibrator for around 4 minutes.
- 9) The mortar cubes were demolded the morning after and fully submerged in water.
- 10) After seven days of curing the three cubes were taken out of water, and one of them was weighed at the submerged and the saturated surface dry conditions, and then it was crushed using the compressive crushing machine. And the other two were weighed and crushed on 14<sup>th</sup> and 28<sup>th</sup> day.

## - Instruments

### Apparatus and Tools:



fig(1): sand



fig(2): normal portland cement



fig(3): 7mm cubical molds



fig(4): water squarer



fig(5): trowel and tray



fig(6): mold vibrator



fig(7): compressive crushing machine



fig(8): Vicat apparatus



fig(9): balance



fig(10): stopwatch



- **Data & Calculations:**

Table(1): standard consistency data				
trial	Cement Weight (gm)	Water (%)	Water Weight (gm)	Penetration from bottom (mm)
1	300	37	111	0
2		36	108	2
3		35	105	5
4		34.5	103.5	6

Table(2): setting time of cement data			
Type of cement: Normal Portland cement			
Time of adding water: 9:30 am			
trial	Clock time	Elapsed time (hour)	Penetration from bottom (mm)
1	11:00	1:30	0
2	12:00	2:30	0
3	13:00	3:30	5 (initial)
4	14:40	5:10	final

Table(3): cement mortar test data							
Specimen	Age (days)	$W_{sub}$ (gm)	$W_{SSD}$ (gm)	P (KN)	$\rho$ (gm/cm <sup>3</sup> )	A (cm <sup>2</sup> )	$\sigma$ (MPa)
1	7	417.5	745	127.5	2.27	49	26.0
2	14					49	
3	28					49	

## - **Results & Conclusion**

- Standard consistency = 34.5% water.
- Initial setting time = 3:30 hours.
- Final setting time = 5:10 hours.
- Mortar test results refer to table(3).

Both the initial and final setting times fall within the ranges suggested by the ASTM standards which are 2 to 4 hours for initial and 5 to 8 for the final.

(conclusions of the mortar test will be attached after crushing the rest of the cubes ).

Sources of error:

- Loss of material while mixing.
- Poor timing using the stopwatch.
- Water leakage from the Vicat mold.
- Poor or excessive lubricating of molds.
- Poor weighing.
- Balances maladjustment.
- Molds deformations.

## - **References**

- Civil Engineering Portal
- (<https://www.engineeringcivil.com/test-to-check-consistency-of-cement.html>)
- Civil read

<https://civilread.com/cement-initial-final-setting->

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