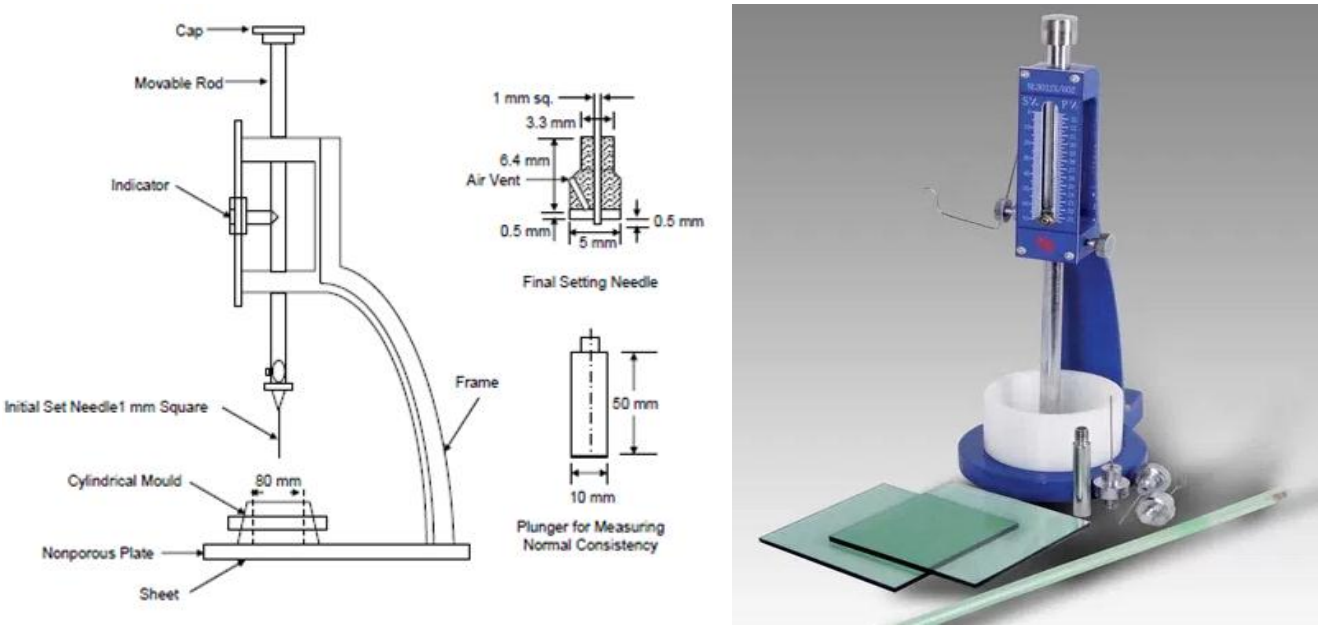
Lecture 5

Physical properties of cement

A- Standard consistence of cement

The amount of water to give cement its standard consistence is called typical w/c ratio. However, this is from physical aspect, and might not be the typical one for complete hydration of cement from a chemical point of view. Vicat instrument uses for this purpose according to ASTM C 187– 98 (The test should be covered at lab. course- main principle should be explained briefly here)



Vicate instrument for standard consistence and setting of cement

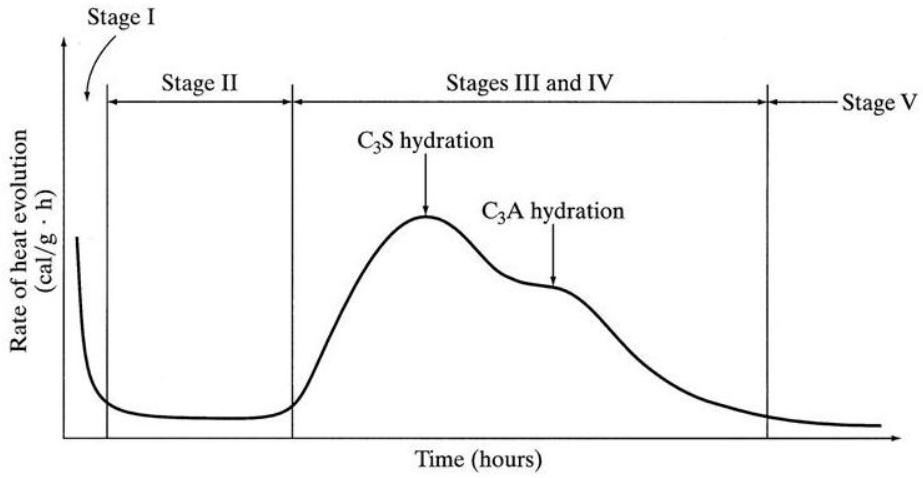
B- Setting and hardening of cement

After mixing with water, there are mainly two type of setting:

1- Initial setting: it is the time required for doing the primary operation such as mixing, handling, casting and finishing. It starts from the addition of water and the IQS limit is: (not less than 45 min. why?)

2- Final setting: it is the time required for hardening and the IQS limit is: (not more than 10 hrs. why?)

Setting stages:



Cement setting stages (heat of hydration vs time)

1- Stage 1: for several minutes after mixing with high rate of hydration heat.

2- Stage 2: between 1- 4 hrs (dormancy stage) why?

3- Stages 3 and 4: reactivation of reaction at max. heat of hydration at about 6 hrs.

4- Stage 5: hardening stage (initial strength gain stage)

What is the difference between setting and hardening of cement?

Setting of cement depends on: chemical composition, w/c ratio, fineness of cement and temperature. (How can these factors affect setting?)

Types of setting according availability of C3A and SO_3

Type	C3A	SO_3	Time
Normal setting	high	high	2-4 hrs
Normal setting	low	low	1-2 hrs
Quick setting	high	low	10-45 min.

Flash setting	high	Very low/none	≤ 10 min
False setting	low	high	≤ 10 min

False setting is not a real setting with very low heat of hydration and the consistency can be reobtained by remixing. Its causes are: dehydration of Gypsum, bad storing of cement and activation of C3S due to that.

What is the rule of each factor above to cause false setting?

- Try to differentiate between all the types!
- Vicat instrument can be used for Initial and final setting test should be covered by lab. course – explain briefly here).

C- Soundness of cement

The test of soundness of cement is to ensure that the cement does not show any appreciable subsequent expansion.

The unsoundness in cement is due to

1- The delayed or slow hydration.

2- The presence of an excessive amount of lime (CaO).

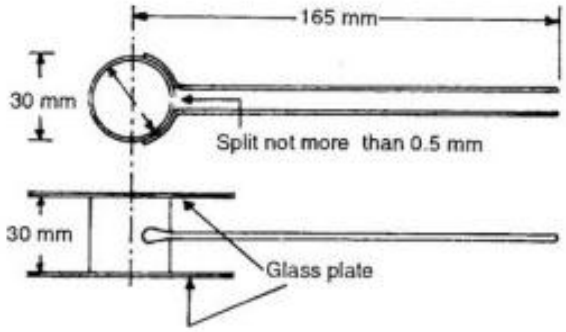
3- Excessive amount of magnesium oxide.

4- Excessive amount of sulphates.

Because unsoundness of cement is not appear until after a period of months/years, therefore, accelerated tests are required to detect the unsoundness of cement. The cement soundness could be tested by two methods:

1- Autoclave Test, ASTM C 151-09

2- Le Chatelier Test, BS EN 196-3:2005 (should be covered by lab. course – main principle should explain briefly here)



Le Chatelier test for soundness of cement

D- Fineness of Cement

Measured in m^2/kg and it affects the rate of hydration directly (increase of fineness means rapid hydration and hardening. However, there are several disadvantages of increasing the fineness of cement:

1-An increase in cost due to clinker grinding

2- Difficulty in storing due to rapid hydration

3- Could increase drying shrinkage

4- An increase in Gypsum required for controlling setting of cement

5- Could increase the Alkali- silica reaction due to high alkalis' surface area

Tests

1- Sieve Method

It is the classical method to measure the cement fineness. The return percent of cement on sieve No.170 (90 μm) according to BS (British Standard) should not exceed 10% for ordinary Portland cement.

According to American Standards ASTM, the return percentage on sieve No.200 (74μm) should not exceed 22%.

2- By determination of specific surface

a- Wagner Method, ASTM C115-10

b- Air-permeability Method, BS 12:1971

c- Blaine Method, ASTM C204-07-, BS EN 196-6:2010.

This method used by Iraqi Standards No.5

E- Compressive strength of cement

- Mortar specimens (not paste) should be used why?
- Standard fine aggregate should be used.
- 1 cement : 2.75 fine aggregate with a w/c to give a flow of 100-110 mm
- Cubic moulds 50mm or 70 mm.

After knowing the physical properties of cement:

Are these properties important for the concrete in practice and how you can improve some of them?