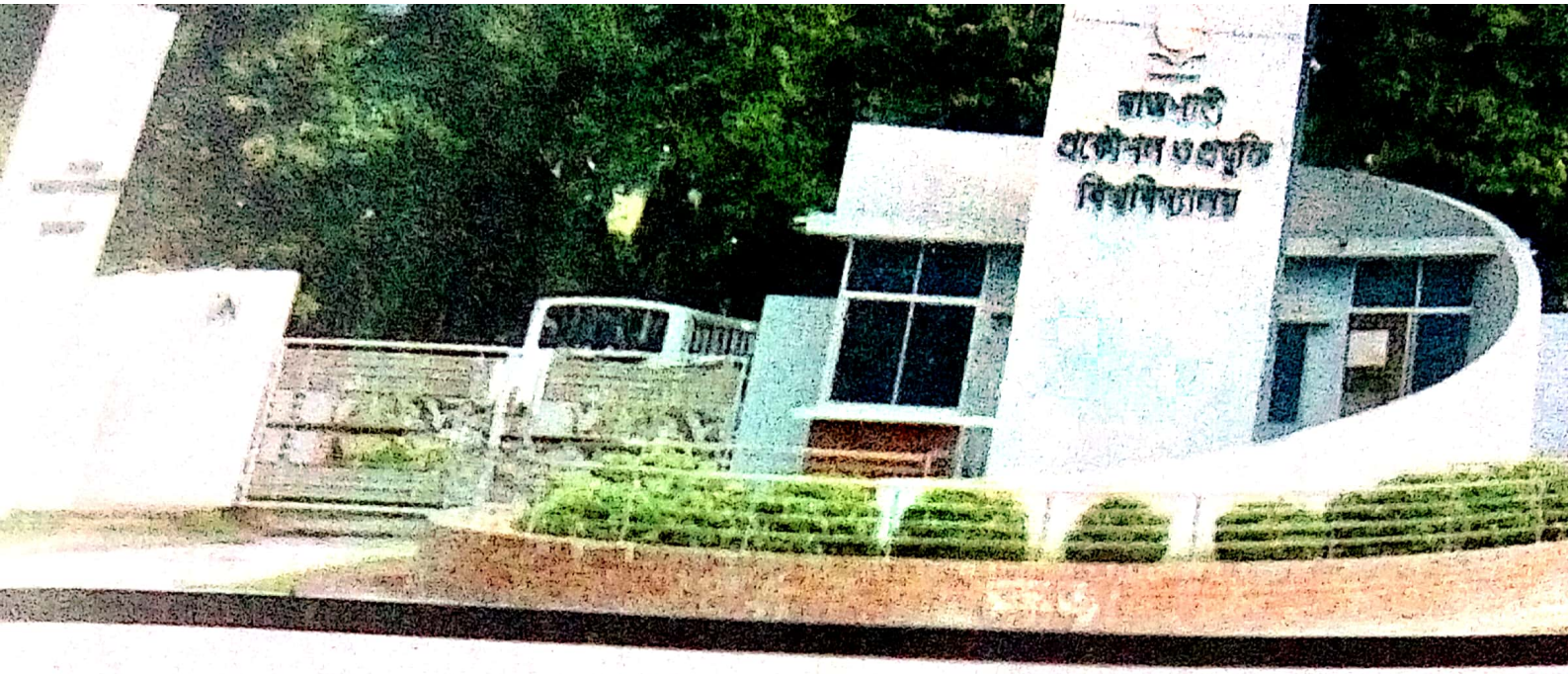

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CE- 2103

22/01/2020

Engineering Materials

Topics:

① Aggregate
② Cement
③ Corrosion
④ Concrete

Aggregate: The inert materials used in concrete are named as aggregate.

It occupies almost 70-80% of total volume of concrete.

কিছু কিছু reaction ও আছে → baotanical aggregate (as example)

Types →

① Fine aggregate [মিহিন দানা]
② Coarse " [মোটা দানা]

Fine Aggregate: Sand and surki are commonly used as fine aggreg

Stone screenings, burnt clays, fly ash are also used as substitud
(পাথর চালা)
of sand.

→ 3/16" / 4.76 mm / #4 ASTM Sieve

↓

American Society of Testing Materials

এটা দিয়ে চাললে যেগুলো pass করে যাবে → fine agg.

Coarse Aggregate: Brick, Khoa, broken stone, gravels, pebbles etc are used as coarse aggregate.

Size: $\frac{3}{16}$" ~ 2" ——→ general

(based on purpose of the construct, design of the structure)

G_{max} ——→ maximum size of gravity / aggregate.

Ex: G_{max} = 19 mm

* Grading of Aggregate:

A suitable gradation is required of the combined aggregate in the concrete mix due to ——→

① Secure workability.
② Economy in cement use.
③ Higher density gathered.

বিভিন্ন ingredients বিভিন্ন shape or size এ mixture করা হয়

↳→ Grading

Vol same,

gradation ভালো — cement কম

density & strength

suitable grading.

↳ workability increase or decrease করে secure করতে হবে।

fluid movement হবে

Principle of gradation:

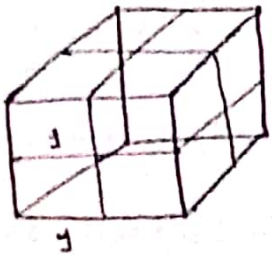
The smaller particles will filled up empty pores in between larger particles.

(same size)

→ vol বেশি : density বেশি
surface area বাড়ি গেল কমে।

√ same → smaller particle size → surface area বাড়বে।

Surface area = $6 \times 2^2 = 24$



Surface area = $6 \times 8 = 48$

Sand: It is an engineering material named as fine aggregate. and made be of sharpe, angular or rounded. may

Classification:

According to source:

① Pit Sand: ① Sharp, angular, porous. (irregular shape)

② Free from salts.

③ It may contain clay or other impurities that should be screened and washed. (wash না করলে strength almost 30% কমে যায়) (ছাকা)

④ ligth brown or yellowish in colour.

⑤ Suitable for mortar work.

#8

⑪ River Sand: ① Fine, round and polished.

② It contains earthy impurities likes grabbles and pebbles.

③ whilish in colour.

④ Suitable for plastering work.

#16

(iii) Sea Sand: ① Fine, round and polished.

② It is the worst among all this three types as it contains sea salt that absorbe moisture causing dampness and efflorescence.

According to size:

Type	Size	Uses
Fine Sand	$\angle$ #16 Sieve ($\frac{1}{16}$")	Plastarily
Moderate Coarse Sand	$\angle$ #8 " ($\frac{1}{8}$")	Mortar
Coarse Sand	$\angle$ #4 " ($\frac{3}{16}$")	Concrete

Use Test of

It is determined by the percent lose of weigth of a sample after wasing the same with clean water.

Test for organic matter: (organic metal থাকলে heat generate করে, এগুলো বায়বকণিকে pore তৈরি করে)

(i) Shaking of the sample of sand with a 3% of Sodium Hydroxide solution in closed bottle.

(ii) It is left for 24 hours as it is.

(iii) If the colour turns to brown, organic metal is present.

Bulking of Sand:

(The presence of moisture in sand increase its volume.)

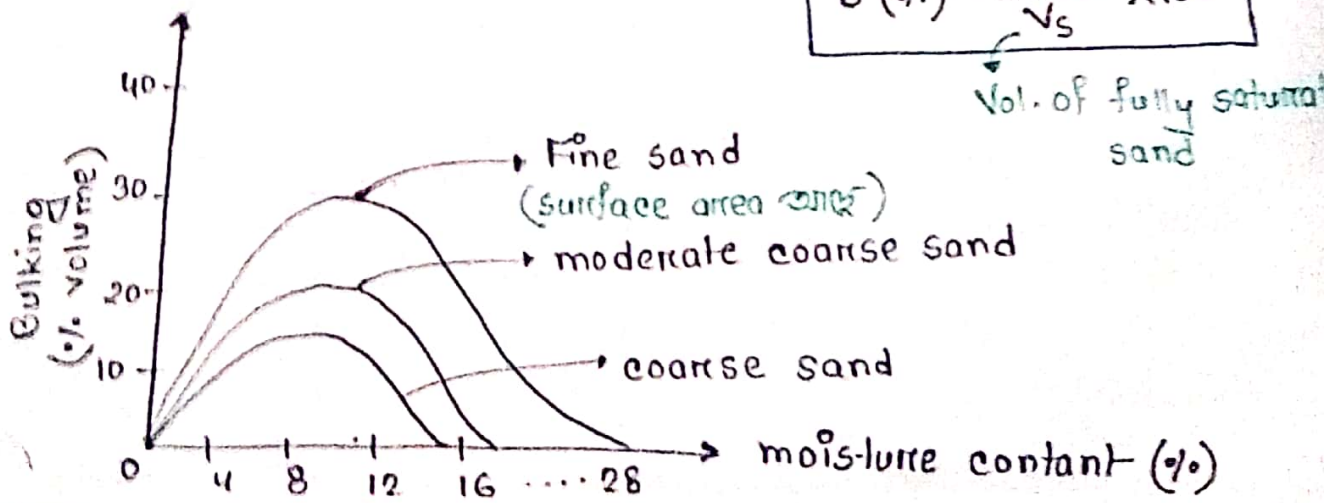
This is due to the fact that a thin film of water is falled foun formed around the sand grains. That results increase in the volume. This phenomena is called bulking of sand.

5 to 8% moisture by weigth of sand steadily increase its volume upto 20-30%.

Vol. of moisture sand

$$b\,(\%) = \frac{V_m}{V_s} \times 100$$

Vol. of fully saturat sand



Fineness Modulas:

Fineness modulas is an imperial formula obtained by taking the sum of cumulative percentages of sand retained on standard sieves (3", 1½" ..... #100) and dividing by 100. The value should be between 2 to 8.

low value (<2) → the materials should be used as filling materials.

$$F_{com} = \frac{m_1F_1 + m_2F_2 + \dots}{m_1 + m_2 + \dots}$$

F_{com} = Combined fineness modulas.

$F_1, F_2, \dots$ = Fineness modulas of sample 1, 2, ...

$m_1, m_2 \dots$ = amount of sample 1, 2, ...

Following is the result of sieve analysis of two different sands: (1500gm each)
Find combined fineness modulas.

Sieve	wt. retained (1)	wt. retained (2)	Cumulative wt. retained (1)	cumulative wt. retained (2)
3"	0	0	0	0
1½"	0	0	0	0
¾"	0	0	0	0
3/16"	0	0	0	0
#4	20	0	20	0
8	80	60	100	60
16	120	110	220	170
30	280	260	500	430
50	320	390	820	820
100	680	680	1500	1500

% cumulative wt retained (1)	% cumulative wt retained (2)
0	0
0	0
0	0
0	0
0	0
1·33	4·1.
6·67	11·33·/.
14·67	28·67
33·33	54·67
54·67	100
100	
210·67	198·67

$\frac{20}{1500} \times 100$

$$F_1 = \frac{210.67}{100} = 2.11$$

$$F_2 = \frac{198.67}{100} = 1.99$$

$$F_{com} = \frac{2.11 \times 1500 + 1.99 \times 1500}{1500 + 1500}$$

$$= 2.05$$

Surki: Surki is made by grinding fresh and well burnt bricks.

(i) It should be perfectly clean.

(ii) Free from foreign matter.

(iii) Sufficiently fine to pass through #8 sieve.

Uses:

(i) Lime mortar.

(ii) Lime plaster.

(iii) Lime concrete. (L.C)

Alkali Aggregate Reaction (AAR):

- Alkali in concrete + Reactive aggregate ⇒ Reacted Product
- Reacted product + water ⇒ Expansion / Crack

concrete এর pH → 12 to 13

Alkali in concrete + Reactive Aggregate ⇒ Reacted Product

↑ Reduction of alkali

- # Use low Alkali cement
- # Use of admixture (cement, H_2O, agg. concrete এর) (GBFS, F.A), Fly Ash
  - ↳ Granulated blast furnest slag

↑ Elimination of reactive aggregate

- # Chemical method
- # Mortar bar method

better not to use reactive aggregate

If reacted product reacts with water and crack →

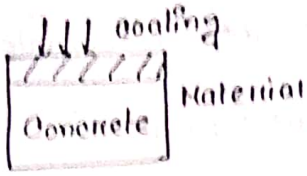
1. Map cracking
2. Reduction of strength
3. Poor durability → অত্যন্ত কম life span, অত্যন্ত কম maitainence খরচ exist করে
4. Poor water tightness

* Crack হলে load carry capacity কমে যায় → surface area কমে যায়.

Reacted Residual + Water → Expansion / crack

↓

Reduce permeation



Cement

Cement: Cement is a crystaline compound of calcium silicate and other calcium compound having hydraulic properties.

It means they react and harden chemical with addition of water. It contains lime stone, clay, rock, iron ore blended and heated to a temperature of 1200 - 1500°C. The resulting clinker is ground to a consistancy of powder and gypsum is added.

1824 - Joseph Aspdin. - portland cement

Calcium product → lime stone, chalk ($CaO + CO_2$) → 2/3 of total

Silicate product → clay, shale, ($SiO_2 + Al_2O_3 + FeCO_3$) → 1/3

Suitability of cement over lime:

Cement is superior than lime with respect of →

(i) Construction of structure in wet place or under water.

(ii) Heavy strength and durability is required.

(iii) Mortar and plaster has to set quick and attains its strength.

(iv) Used for water tight structure.

(v) Decorative, ornamental and pointing works.

(vi) Hard surface is required against weathering action.

→ surface দৃঢ় হবে না (durability বাড়বে)

Oxide composition of ordinary cement

Oxide	Composition (%)
CaO	60-67
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-6
MgO	0.1-4
Alkali (Na_2O, K_2O)	0.4-1.3
SO_3	1-3

The above oxides present in the raw material when subjected to clinkering temperature, combined one with another to form a complex compound called bogue's compound.

	Symbol	Formula	%	Colour	
(i)	C_3S	$3CaO.SiO_2$	54	Red	responsible to gain strength
(ii)	C_2S	$2CaO.SiO_2$	16.6	aqua	
(iii)	C_3A	$3CaO.Al_2O_3$	10.8	Green	
(iv)	C_4AF	$4CaO.Al_2O_3.Fe_2O_3$	9.1	Yellow	

Functions of various components of cement:

• Lime (CaO):

1. Deficiency causes strength reduction.
2. Lack of CaO results quick setting.
3. Excess will make the cement unsound.
4. Excess causes expansion and disintegration.

• Magnesia (MgO):

1. It imparts hardness.
2. Helps to form colour.
3. Excess will make cement unsound.

• Silica (SiO_2):

1. It helps to gain strength.
2. Setting time increases.

• Alumina (Al_2O_3):

1. It imparts quick setting properly.
2. Excess weakens the cement.

Setting → bearing capacity gain করায়না

hardness → bearing capacity

* Setting time change করা যায় manufacture এর আগে।
(before manufacturing we can adjust time)

• Calcium salfate ($CaSO_4$):

It is present in the form of gypsum ($CaSO_4 \cdot 2H_2O$)

1. It increases initial setting time of cement.
2. It stabilizes heat of hydration.

Property of cement:

1. It gives strength to the masonry (brick work).
2. Excellent binding material.
3. Easily workable.
4. Good resistance to the moisture.
5. It passes good plasticity.
6. It sets and hardens.

17/02/2020

Site selection for cement factory:

Following are the key factors to be paid attention while making the selection for cement factory:

(i) Climatic conditions: The site should be such that the area climate is favourable for the manufacturing process.

(ii) Labour: a) easily available labour.
b) economy in labour charge.

(iii) Market: The factory should be closed to the market to reduce the transport cost.

(iv) Power: a) availability of the power.
b) low cost fuel.

(v) Raw materials: a) easily available around the factory.
b) continuous supply of the material.

(vi) Transport facility: It should be smooth to carry raw materials and the finished products.

Uses of cement:

(i) Cement-mortar for masonary, plastering, pointing works (brick type)

(ii) Manufacturing of concrete that is used for structures like buildings, bridges, tunnels etc.

(iii) Making joints for pipes, drains etc.

(iv) Preparation of foundation, water tide, floor, foot-path etc.

(v) Used as coating material to resist the penitration of (মুহূর্তের মধ্যেই প্রবেশ) deleterious materials.

Types of cement:

synonym

(i) Ordinary portland cement (OPC) [mother of cement]

(ii) Acid resistant cement

(iii) Blast furnace cement

(iv) Expansive cement

(v) High alumina cement

(vi) Low heat cement

(vii) Pozzuolona cement

(viii) Quick setting cement

(ix) Rapid Hardening cement.

(x) Sulfate resisting cement.

(xi) White cement.

Expansive Cement: The cement which suffers no overall change in the volume on drying, is known as expansive cement.

8 – 20 parts of sulpho-aluminate clinker is added to 100 parts of portland cement. It works against drying shrinkage.

Uses:

(i) It is used in water retaining structure.

(ii) In the repairing works.

(যেখানে vol. shrink করে, ঐখানে expansive cement use করলে vol. constant থাকবে → drying shrinkage কে compensate করে।

পানি আরে গেলে cement reduce হয়ে agg. এর দিকে চলে যেতে চায়। একে compansive করবে। (verticle crack

liquid retaining structure এ কম temp. এর জন্য reduce করে একে compansive করবে → একে repair করা যায়।)

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High alumina cement:

Advantage:

① The initial setting time is more than 3½ hours. Thus it allows more time for mixing and placing operations.

② It can stand high temperature.

③ It resists action of acid.

④ It sets quickly and attains higher strength in short time. (Final setting time)

⑤ Not affected by CO_2. desolve in pure water. and is therefore suitable for manufacturing pipes.
(waste water এর সাথে মিশে concrete pipe তৈরির জন্য উপযুক্ত)

Disadvantage:

① It can not be used in mass concrete. → বেশি তাপ উৎপন্ন হয় for A
concrete বেশি internal crack হয়

② It is costly.

24/02/2020

Pozzulana Cement:

It is a siliceous material, which while in itself possessing no cementicious properties, will in finely divided form and in the presence of water, reacts with calcium hydroxide.

* নিজের cementing গুন নাই। কিন্তু parts replace করে use করা হয়,
* OPC থেকে Pozzulonic cement এর capacity কম থাকে, তাই দিন যত OPC থেকে better strength হয়,
* Pozzulonic material add করা হয়,

Characteristics:

(i) The pozzulona constituent shall not be less than 10% and not more than 25% by weight of portland pozzulona cement. (commercialy)

(ii) The specific surface area of pozzulanic cement shall not be less than 3000 sqcm/gm. (cement এর particle size হয়)

(iii) The compressive strength of this cement should not be less than 220 kg/sqcm at 7 days. and should not be less than 310 kg/sqcm at 28 days.
→ concrete এর জন্য

Advantages:

(i) It attains compressive strength with the age.

(ii) It resists action of sulfate.

(iii) It involves less heat during selling.

(iv) High water tightness.

(v) It is cheap.

Disadvantages:

(i) The compressive strength in the early age is less.
(প্রথম অবস্থায় অসুবিধা আছে)

(ii) Less resistant to the erosion and weathering action.

* durability based ⟶ pozzulona
↓
particle size অনেক ছোট
(permeabily কম, temp কমে যেখানে)
↓
যেহেতু OPC এর % কম থা

Rapid Hearndening Cement:

It is recomended under the following cases →

(i) In the pre-fabricated concrete construction.

(ii) where the formwork is required to be removed early and reused elsewhere → shuttering (cost কমে যায়, moveable হয়)

(iii) Road repairing works.

(iv) Impo In cold weather concreting.

Advantage:

(i) The construction work is speedy. (Quality and timeshedule)

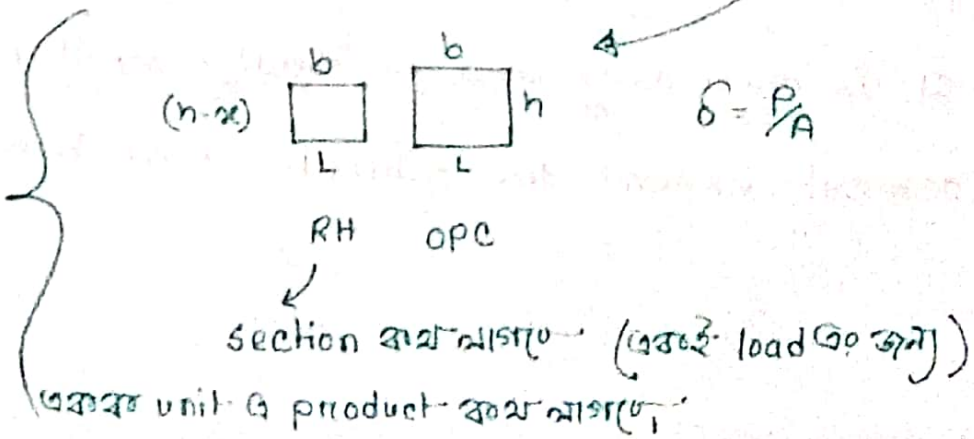
(ii) Formwork can be used frequently.

(iii) It requires short period of curing. → পানি (বের না হওয়া)

(iv) It allows higher permissible stress. and thus it is economical

Disadvantage:

(i) Costly. (Permissible stress high)



02/03/2020

Type-I cement: (general use-সাধারণ ব্যবহার)

It is general purpose cement used in the concrete for making pavements, floors, bridges, buildings, tanks, pipes etc.

It is used for all uses where special properties are not required such as sulfate action, objectionable temp rise etc.

Type-II cement: (moderate sulphate)

It is used where precautions against where moderate sulfate action is important. It contains no more than 8% of C_3A. It usually generates less heat at a slower rate than type-I cement. Therefore, it can be used in the mass concrete. → (piping, drainage, hot weather country)

It is also preferred in the hot weather concreting.

Type-III cement: (Rapid hardening)

It is chemically and phisically similar to type-I cement: except the particles have been ground fine

It provides high early strength usually a week or less. It is used where the formwork needs to be removed as early as possible. It is also preferred in the cold weather concreting. (Rapid hardening)

particle size more finer → surface ↑ hydration (शक्ति → strength (शक्ति

Type - IV cement: (like pozzolanic cement)

It is used where the rate and amount of heat generated by hydration must be minimized. It develops strength at a slower rate than other cement. It is most suitable for massive concrete to controll the crack generation.

Type - V cement: (Severe Sulphate)

It is used where the concrete is exposed to severe sulpha condition. It contains C_3A about 4%.

Type - IA, IIA, IIIA

These cements have similar compositions as type I, II and III respectively except small quantities of I, II, III ← air entraining materials are inter ground with additional admixture the clinker in the time of manufacture.

→ liquid (type - IIA, IIA, IA) manufacturing এর সময়ে

→ powder

air { entrapped air → bad → connect হলে permeability বাড়ে
(যত বেশি finer entrapped air (বড় কণা অপসারণ)
entrained air → good → (সূক্ষ্মাকৃত রূপে add করা)
→ connectivity থাকে না।
stress নেয়ার জন্য, নাহলে internal crack হবে

Testing of cement

a) Field test

b) Lab test

a) Field test:

(i) In a cement bag, there should not be any visible lumps.

(ii) The colour should be greenish gray.

(iii) If you thrust your hand into a cement bag, it must give a cool feeling.

(iv) Feel a pinch of cement in beln fingers, it must not give a gritty feeling. (এন হাতের finger এ কোন particle থাকবে)

(v) Take a hand full of cement and ~~through~~ throw it into a bucket full of water, it should float sometimes before it sinks.

05/02/2020

(b) Lab test:

a) Fineness test → surface area measure করা.

b) Setting time test

c) Strength test

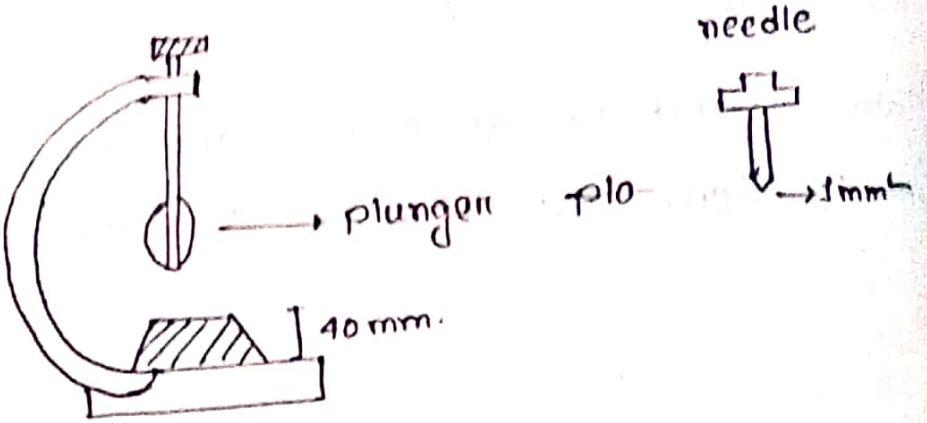
d) Soundness test → la-shate-lier law (heat এ কি ভাবে expand measure) 10mm এর sound.

e) Heat of hydration test → large project

f) Chemical composition test

Standard / normal consistancy of cement:

The standard consistancy of a cement paste is defined as that consistancy which will permit a Vicat apparatus plunger having 10 mm dia. and 50 mm length to penetrate to a depth of (10±1) mm from the top of the mould.



Amount of water for which we can get consistancy.

water বৃদ্ধি ⟶ penetration বৃদ্ধি।

Initial setting time:

It is regarded as the time elapsed betn the moment the water is added to the cement to the time the paste starts using its plasticity.

During the test it is specified as the period elapsed

betn the time when the water is added to the cement and the time at which the Vicat apparatus middle needle penetrates the test block 25 mm from the top.

1mm² area.

শুরুতে water যোগ্য → penetration যোগ্য হবে।

Final setting time:

The time elapsed betn the moment the water is added to the cement and the time when cement paste has completely lost its plasticity and attains sufficient strength to resist certain pressure.

During the test it is specified the period elapsed from the water is added to the cement to the time at which the Vicat apparatus needle doesn't not penetrate more than 0.5 mm.

t=0 → cement + water

t=0 ——— ti ——— 0.5mm. tf
25mm

pressure দিলে water particle বাহির হয়।

Setting time	OPC	Rapid Hardening Cement RHC	Low Heat Cement LHC
Initial	30	30	60
Final	600	600	600

False setting:

It is the name that indicates abnormal premature stiffening of the cement paste within few minutes of mixing with water without revolving any heat.

Causes:

① Dehydration of gypsum when interground with too hot clinker

gypsum এ পানি কমে গেলে setting time কমে যায়; যাকে false setting বলে।

$CaSO_4 \cdot 2H_2O$
↓
$CaSO_4 \cdot \frac{1}{2}H_2O$ → Semihydrate
↓
$CaSO_4$ → Anhydrate

Carbonation

② Excess alkali (CaO) present in cement when carbonates and precipitates induce rigidity.

(iii) Activation of C_3S by air circulation at moderate high humidity.

→ early strength gain होता है।

Chemical requirements of cement:

Name of the chemical	Range
(i) Ratio of percentage of lime to the percentage of silicat, alumina and iron oxidide when calculated by this formula $\frac{CaO - 0.7SO_3}{2.8SiO_2 + 1.2Al_2O_3 + .65Fe_2O_3}$	not greater than 1.02. not less than 0.66.
(ii) Ratio of percentage of alumina to that of iron oxide	not less than 0.66.
(iii) Weight of insoluble residue.	not more than 2%.
(iv) Weight of magnesia	not more than 6%.
(v) Total sulphate % by mass.	a) not more than 2.75%. → when $C_3A \leq 7\%$ b) not more than 3%. → when $C_3A > 7\%$

(v) Total loss of ignition	not more than 5%.