Lime:- [Introduction]

Lime is an important binding material in building construction

① when it is mixed with sand and water, the mixture is called as lime mortar and it is used to bind bricks and stones of walls to f[orm] a solid mass called masonary and also as a plaster on the walls

② when it is mixed with sand coarse aggregate and water, the mixer is called as lime concrete and it is used as filler or concrete bed for foundations and as base coarse for flooring in buildings.

③ Lime is also used for production of artificial stones, lime sand bricks, silicate products etc.

④ It is also used for stabilising soils for white washing and also form the basic material in colouring washing etc.

→ Manufacture of lime:-

Lime is basically calcium oxide (CaO) in natural association with magnesium oxide (MgO). calcium oxide is available in nature in the form of limestone which has large proportion of calcium carbonate ($CaCO_3$) in combination with magnesium carbonate [$MgCO_3$] oxide of iron [FeO], alumina [Al_2O_3] and silica [SiO_2].

Basic principles:-

① chemical reaction:- when heated to a temperature of 900°C the calcium carbonate [$CaCO_3$] in limestone liberates carbon dioxide (CO_2) to produce calcium oxide [CaO] which is pure lime.

2. Optimum conditions for effective reaction:-

To get the maximum output of pure lime from limestone, it is important to pay attention to the following factors.

(a) To maintain the temperature of 900°c or more throughout the kiln space.

(b) To maintain the uniformity of burning by supplying the kiln with appropriate sizes of lime stone and fuel.

(c) To maintain smooth movement of the exhaust gas (CO_2) to reuse the heat for economy.

Operation factors:-

Temperature in kiln:-

For each type of lime stone there is a temperature range of calcination which will give the best burning. At 900°c limestone liberates carbon dioxide at a fairly rapid rate. For faster rate the temperature should be over 900°c. Normally the temperature in the calcination zone is maintained between 1000°c and 1300°c.

For maximum efficiency the temperature of the exhaust gas should be as low as possible. For a natural draft it is maintained at 200°c to 300°c. Excess heat is utilized to preheat the incoming raw materi

Temperature of drawn lime should be as low as possible, but not greater than 100°c.

Size of the lime stone:- Larger the size of lime stone fed in to the kiln larger is the time required for heat to reach the centre of the lime stone.

Sl-No	Description of kiln	Size of limestone
1.	kiln with shafts of effective heights about 12.00m	10-15 cms
2.	kiln with shafts of effective heights about 7.50m	7.5-10 cms

→ Manufacturing process:-

Raw material:- As stated above the kiln is fed with (i) coke (ii) coal (iii) lime stone (predominantly containing $CaCO_3$)

stage of operation:- The manufacture of the lime consists of the following four stages.

(a) charging (b) calcining (c) drawing and (d) hydrating

(a) charging:- charging is the operation of manually or mechanically feeding the kiln at the top with lime and fuel.

(b) calcining:- calcining is the operation of converting lime stone in to quick lime by heating it to temperature over 900°c and releasing carbondioxide.

(c) Drawing:- Drawing is the operation of manually or mechanically with drawing the quick lime from the bottom of the kiln.

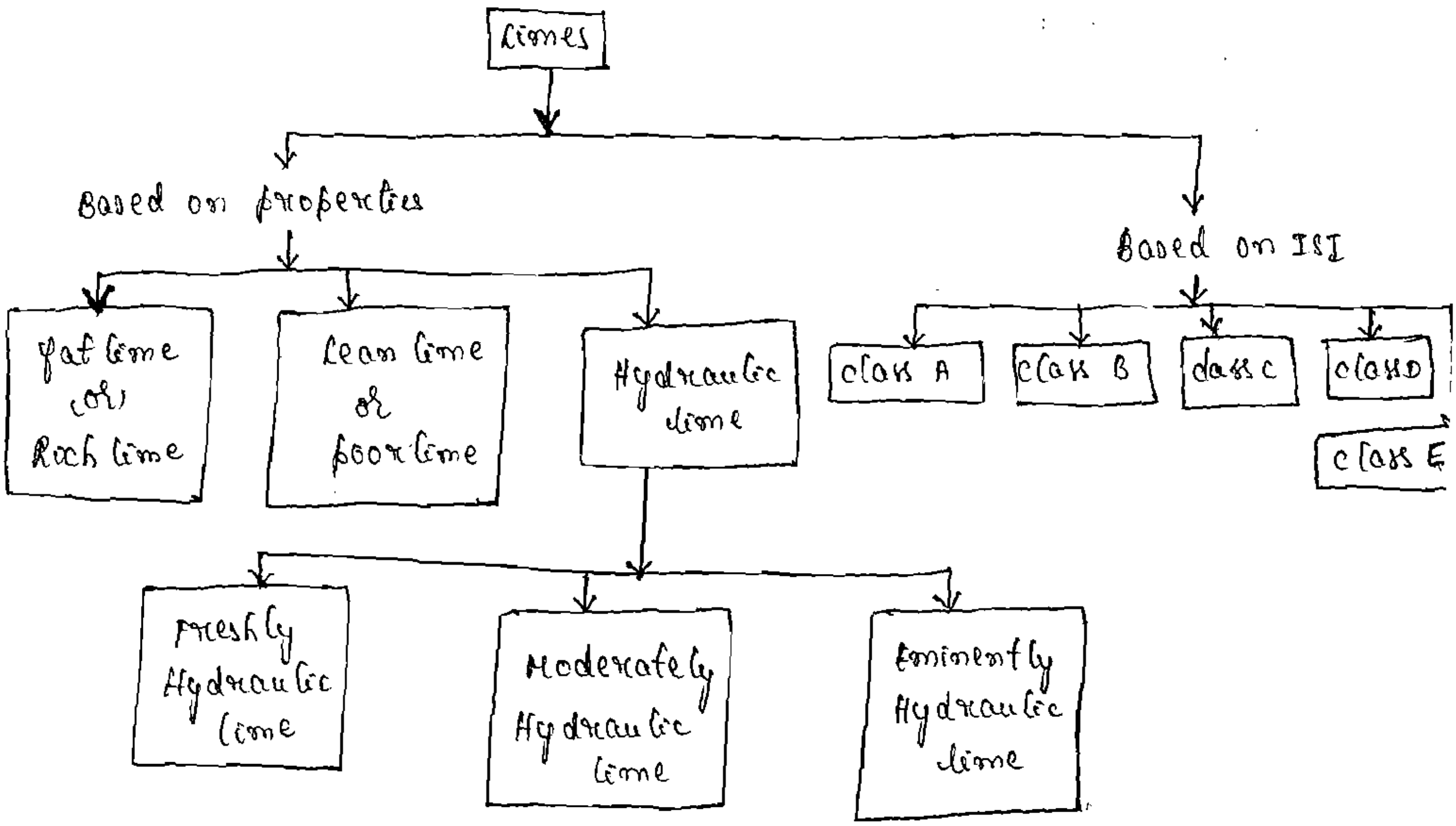
(d) Hydrating:- Hydrating is the process of obtaining hydrated lime by addition of water to quick lime.

→ properties of lime:-

The important properties of good quality of lime which make it suitable for use as construction material are:-

① It posses good plasticity
② It is easily workable.
③ It stiffens early.
④ It gives strength to the masonarey.
⑤ It adheres perfectly to the masonarey units.
⑥ It offers good resistance to moisture.
⑦ ~~Shrema~~ Shrinkage in drying is low and hence durable.

→ Classification of lime:-



As the lime is obtained from various, sources differs considerably in its composition, there are different kinds of limes each having different slaking and setting properties. Various limes may be

① Fat lime or pure rich lime.
② Lean or poor lime
③ Hydraulic lime.

Fat lime:- This type of lime is obtained by the calcination of nearly pure lime stone. mostly it contains calcium oxide - slaking is rapid with considerable evolution of heat. During slaking this type of lime swells from two or three times of its original volume.

Lean or poor lime:- It contains more than 10% of clayey impurities in the form of silica, alumina and iron oxide. It takes more time to slake. setting and hardening is extremely slow. Its colour varies from yellowish, white to grey depending on its iron content

Hydraulic lime:- The raw lime stone from which hydraulic lime is prepared contains 5 to 30% silica and alumina ~~from~~ with some iron oxide. These will be in chemical composition with the calcium oxide content.

when the sand is added to the lime for preparation of mortar with more water, complicated chemical reaction takes place. During this process, hydrated salts of calcium silicates and calcium aluminates are formed. These hydrated salts crystallize and form a hard substance which has a great strength.

The setting of hydraulic lime is independent of the presence of carbon dioxide. This is the reason for using hydraulic lime in all most all thick wall constructions. Also the setting of hydraulic lime in all most all thick wall constructions. Also the setting of hydraulic lime depends on water and is therefore more suitable for use in structure under water. Hydraulic lime may be further divided in to

① Feebly hydraulic lime:-

The total content of silica, alumina and iron oxide will be about 5 to 10%. It slakely slowly and expansion on slacking is not vigorous. mortar made from this lime is used for less important works.

② Moderately hydraulic lime:-

In this class, the total quantity of silica, alumina and iron oxide varies from 10 to 25%. It slakes very slowly and expansion of slaking is sma... The mortar mode from this lime considered to be good.

③ Eminently hydraulic lime:-

This contains 25 to 30% of the clayey ingradients (i.e) silica, alumina and iron oxide) and its chemical composition resembles very much with ordinary portland cement. The slaking in this lime is rarely noticeable. The initial set starts after 2 hours and the final set with in 48 hours. This class of lime is commonly used for structural works under water or in damp situations.

→ cement:-

cement is commonly used binding material in the construction. The cement is obtained by burning a mixture of calcarious (calcium) and argillaceous (clay) material at a very high temperature and then binding the clinker so produced to a fine powder. It was first produced by a mason Joseph Aspdin in England in 1924. He patented it as a portland cement.

properties of cement:-

① It gives strength to the masonary works.

② It is an excellent binding material.

③ It is easily workable.

④ It offers good resistance to the moisture.

⑤ It posses a good plasticity

⑥ It hardens early.

→ Ordinary portland cement:-

The ordinary portland cement has been classified as 33 grade [IS269 : 1989] 43grade [IS 8112 : 1989] and 53grade [IS 12669 : 1987]. The physical requirements of all these three types of cement are almost same except for compressive strength and are as follows.

S.No	physical requirement	Grade		
		33	43	53
1.	Fineness [m^2/kg]	225	225	225
2.	soundness	10mm	10mm	10mm
3.	setting time (minutes)			
	Initial (minimum)	30	30	30
	final (maximum)	600	600	600
4.	compressive strength [mpa] not less than			
	72 hours (3days)	16	23	27
	168 hours (7 days)	22	33	37
	672 hours (28days)	33	43	53

→ Chemical composition of ordinary portland cement:-

The ordinary cement contains two basic ingradients namely, argillaceo (clay predominates) and calicareous (calcium carbonate predominates)

A typical chemical Analysis of ordinary cement as follows:-

Ingradient	content %	Function
Lime (CaO)	60-67	controls strength and soundness its deficiency reduces strength & setting time.
silica (SiO_2)	17-25	Imparts strength. excess cause slow setting.
Alumina (Al_2O_3)	3-8	Responsible for quick setting, if in excess, it lowers the strength weakness the cement.
Iron oxide (Fe_2O_3)	0.5-6	Gives colour, hardness & strength to the cement.
Magnesia (MgO)	0.1-4	Gives colour hardness. if in excess it causes cracks in mortar.
Sulphur [SO_3]	1.3-3	A small amount of sulphur is useful in making sound cement. If its in excess, it causes cement to become unsound.
Alkalies [$Na_2O + K_2O$]	0.1-0.4	These are residues and if in excess cause efflorescence and cracking.

→ Hydration of cement:-

when water is added to cement a chemical reaction starts which is exothermic in nature and liberate a significant ~~heat~~ amount of heat. This is known as Hydration and the liberated heat is is called the heat of hydration. The process of hydration is not an instantaneous. It is faster in early periods and continuously indefin for a slower rate. In about a month time 85 to 90% of the cement hydrates and the cement attains almost its full strength hydration still continuous and cement grows stronger with time. (5)

The total of 50% of water by mass of cement is required for complete hydration. Thus the water is main ingradient which reacts chemically and cement gains its strength. The rate of hydration is main influenced by

(a) The temperature at which hydration takes place.

(b) The fineness of cement

(c) The ingradients of cement.

→ Heat of hydration :-

The heat of hydration is the heat generated when water and portlan cement react. Heat of hydration is most influenced by the proportion of C_3S and C_3A in the cement, but also influenced by ~~water conten~~ watercement ratio, fineness and curing temperature. As each one of these factors is increased, heat of hydration increases.

For usual ~~usage~~ range of portland cements, about one half of the total heat is liberated between 1 and 3 days about three quarters in 7days and nearly 90% in 6months.

The heat of hydration depends on the chemical composition of cemen

→ classification of cement and their properties:-

Depending upon the need and purposes of utility in construction of structures, the cement is being ~~used~~ manufactured in various types. They are:-

1. ordinary portland cement (or Normal setting cement (opc))
2. Quick setting cement
3. white cement
4. Rapid hardening cement
5. low heat cement
6. High alumina cement
7. Blast furnace slag cement
8. portland pozzolana cement
9. super sulphated cement
10. sulphate resisting cement
11. oil well cement.

① ordinary portland cement:-

properties:- ① It is fine cement when it is sieved in IS NO 9 shall not exceed 10% of the quantity by weight.

② expansion shall not more than 10mm for unaerated cement and not more than 5mm for aerated cement.

③ Initial setting time not less than 30minutes final setting time not more than 600 minutes.

④ compressive strength not less than 11.5N/mm² after 3days and not less than 17.5N/mm² after 7days.

⑤ It has an adequate resistance to dry shrinkage and cracking, but has less resistance to chemical attack.

(2) quick setting cement:-

this cement will have a character of quick setting that is initial setting time of cement is less. This action can be achieved by adding a little amount of gypsum to the cement during the process of grinding clin[ker]. This cement is costlier than ordinary ~~portl~~ portland cement (o.p.c)

properties:-

① Initial setting time is 5 minutes.

② It becomes hard like stone with in 30 minutes

③ It is much finer than opc.

③ white cement:-

It is a variety of ordinary portland cement, which is pure white in colour. The raw materials like china clay and pure lime stone is used to get pure white colour. special care is taken to remove iron oxides during manufacture to avoid the cement colour. only oil is used as a fuel instead of coal dust for burning. The rotary kiln is linked with special fire clay bricks, so that the mixture does not come in to contact with iron and steel during its manufacture.

Note:- ① The strength of white cement is slightly less than that of ordinary cement. It is 4 to 5 times costlier than ordinary portland cement

② It is available at the market under various trade names as "snow crete" Atlas, medusa, silvicrete etc

④ Rapid hardening cement:-

Properties:- ① It contains large proportions of lime than o.p.c

(2) It burnts at higher temperature than o.p.c

(3) It grounds higher than opc.

(4) This cement attains high strength in less time soon after the water is added. This qualities in R.H.C is due to increased lime content and also due to finer barning and burning at higher temperature.

(5) It has high heat of hydration

(6) It is costlier than o.p.c

(5) Low heat cement:-

It is clear fact that the considerable heat is produced during the setting action of the cement. In order to reduce the quantity of heat evolved during chemical reaction that takes place during setting and hardening of o.p.c this low heat cement is used.

properties:-

(1) It contains lower percentage of tricalcium aluminate about (5%) and higher percentage of dicalcium silicate [about 46%]

(2) It possesses less compressive strength.

(3) Its initial setting time is about 60 minutes and final setting time is about 600 minutes (10 hrs)

(4) It attains strength slowly due to its slow action of setting and hardening.

(6) High alumina cement (H.A.C):-

This type of cement is manufactured by grinding clinkers formed by calcining bauxite and lime stone. The bauxite is an aluminium ore. The total alumina content should not less than 32% and the ratio alumina and lime should be between 0.85 to 1.30.

properties:-

1. It has high early strength. In one day it attains the strength of 28days of o.p.c
2. It develops large quantities of heat during setting and hardening
3. Its initial setting time is more than 3½ hours and its final setting time 5 hours. Hence it allows more time in ~~placing~~ mixing placing operations of concrete.
4. It can withstand high temperature.
5. It resists the action of acids in better way.

7. Blast furnace slag cement:-

The blast furnace slag is a waste product obtained during manufacture of iron. It contains the basic elements of cement namely alumina lime and silica.

The slag is first crushed to granulated form and then thoroughly mixed with cement clinkers. The mixing proportion will be 65% of slag and 35% of cement clinkers. Both the components are grained together to form blast furnace slag cement.

properties:-

Its strength in early days is less, therefore it requires longer curing period.

8. portland pozzolana cement:-

The pozzolana is a volcanic powder. It is found in Italy near ~~vescuvia~~ vesuvius. It resembles surki, which is prepared by burning bricks made from the ordinary soil.

while manufacturing of this cement, about 30% of pozzolana material is added to the ordinary cement clinkers. The mixture thoroughly grained well.

⑨ super sulphate cement:-

It is a product of finely grained mixture of granulated blast furnace slag. calcium sulphate and small quantity of ordinary cement. The dry granulated blast furnace slag shall not be less than 70% of weig

⑩ sulphate resisting cement:-

In this cement, the percentage of tricalcium aluminate (C_3A) is kept below 5% and it results in the increasing in resisting power against sulphates.

This cement is used for structures which are likely to be damaged by several alkaline conditions, such as canal lining, culverts syphons etc.

⑪ oil well cement:-

A special type of cement, required for sealing oil wells. sealing is necessary to prevent the side of freshly drilled well form collapsing and keep the ground water out of the well shaft. Also temperature depth of 1000m to 1500m are very high.

The cement meant for sealing should remain in fluid condition for sometime even at these depths. In view of the importance of oil well exploration in India, this type of cement called oil well cement is now being manufactured in India. specially to process all the quantities required for sealing wells.

→ **Laboratory tests of a cement:-**

The following are the laboratory tests of a cement

(a) fineness

(b) consistency

(c) setting time

(d) compressive strength

(e) soundness

→ **(a) fineness test:-**

Aim:- To determine the quality of proper grainding of cement.

Note:- The strength development in concrete is due to the reaction of element particles with water. Thus the larger the surface are available for reaction greater is the rate of hydration and results in increasing the strength of the cement.

The fineness of the cement particles may be determined either by sieve test or by permeability apparatus.

(i) sieve test:- The cement weighing 100gms is taken and it is placed in a standard I.S Test seive NO:9 Breakdown any airset lumps in the sample with fingers. Holding the sieve in both the hands, sieve continously for a period of 15minutes. Then the residue left in sieve may be weighed. The residue should not be more than 10% by weight for opc, and 5% by weight to rapid hardening cement and low heat cement.

ii, permeability apparatus test:-

In this test, the specific surface area of cement particles is calculat the test is better than sieve Analysis test and its gives an idea of unifo fineness. the specific surface acts as a measure of the frequency of the particles of average size. the specific surfaces of the cement should no be less than 2250 cm^2/gm.

→ (b) consistency test:-

Aim:- to determine the percentage of water required for preparing cement paste of standard (or) normal consistency.

Apparatus:- the apparatus required for consistency, initial and final setting time are vicats apparatus as shown in fig. It consists of a frame to which is attached a movable rod weighing 300gms and having diameter and height as 10mm and 50mm respectively. Indicator is attached to the movable rod. this indicator moves on a vertical scale and it gives the penetration.

The vicat mould is in the form of a cylinder and it can be split in to two halves. the vicat mould is placed on the non porous plate. there are three attachments - square needle, plunger and needle with annular collar. the square needle is used for initial setting time test, plunger is used for consisting test and the needle with annular collar is used for final setting time test.

procedure:- the sample of test cement as collected as stated in the topi of sampling shall be sieved to through IS sieve No 9. take 400gms of cement and 100gms of water, mix them thoroughly for 3minutes in a nonporous tray. The paste shall be filled into vicat mould which is placed on a non porous plate (glass or metal ~~plate~~ sheet). Then remo the surplus plate and the level surface of paste with top of the mould with a suitable trowel. Time taken from adding of water to placing of ~~plat~~ paste in the mould is known as "gauging time". It shall not be more than 5 minutes.

The filled mould with porous plate should be placed at the base of the apparatus, centrally below the movable rod to which plunger is attached. Bring the bottom surface of the plunger in contact with the top surface of the cement paste and note down the indicator readings. The rod is then quickly released with out any jerk and note the penetration of the needle in to the cement paste.

Example:- The height of the mould is 40mm. If the plunger rod penetrates by 34mm from the top [ie) 40-34 = 6mm]. It can be expressed as 6mm from the bottom of the paste (mould)

A cement paste is said to be having property of normal consisten when the plunger penetrates in to the cement paste to be penetrate between 5mm to 7mm from the bottom of vicat mould. Test should be completed in 5 to 7 minutes after the mould is arranged on the vicat operators. If above limit of penetration is not achieved, repeat the whole experiment with varying quantities of water till desired penetration is achieved.

Calculations :-

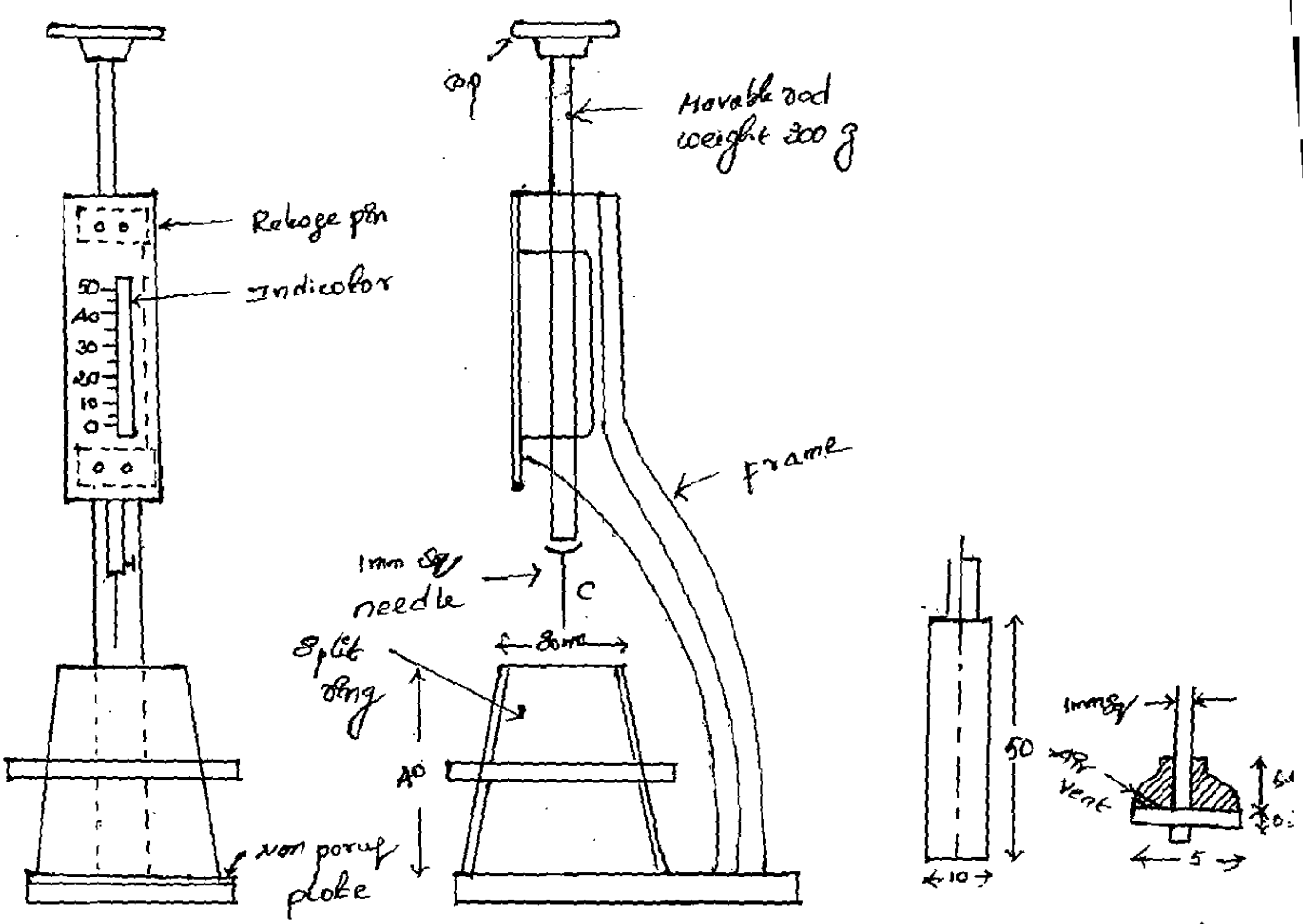
If w is the weight of cement sample

w_1 = wt of water for penetration between to 5 to 7mm from bottom of mould.

p = percentage of water required for normal consistency

then $p = \frac{w_1}{w} \times 100$

Generally for normal consisting p varies between 25 to 35%.



Front view

Side view
Vicat apparatus with needle for initial setting time test

plunger for standard consistency test

Enlarged view

VICAT APPARATUS

→ (c) setting times of cement:-

This test is used to detect the deterioration of cement due to storage. It may however be noted that this is purely conventional type of test and it got no relation with the setting or hardening of actual concrete. The test is carried out to find out initial setting time and final setting time.

(a) Initial setting time of cement:-

Aim: To find the initial setting time of supplied cement sample. Initial setting time is the time takes for proper operations like mixing transportation placing and compaction or finishing the cement mortar or concrete. (Apparatus : vicate apparatus and vicat mould)

procedure:-

① prepare the paste with normal consistency - start the stop watch at the instant when the water is added to cement. prepare the paste and fill the mould as done in the consistency test.

② The mould and the nonporous needle ~~paste~~ plate shall be placed centrally under the rod fitted with ~~wi~~ the square needle of cross section 1mm square or 1.13 dia.

③ Lower this needle gently till the surface of the ~~plate~~ paste. Then quickly release the needle to penetrate in to the paste.

④ In the begining needle may completely penetrate the paste, repeat th procedure until the needle fails to penetrate beyond a point measured

5mm from the bottom of the mould.

⑤ Note down the time for instant.

Note:- ① During the test maintenance maintain the room temperat at 27°c for better result.

② The time taken for entire test for the instant of adding of water to the cement and the time at which needle fails to penetrate the paste at a point beyond 5mm from the bottom of the mould is the initial setting time.

(b) Final setting time of cement:-

Aim:- To find the final setting time of supplied cement sample.

Final setting time is the time taken by the cement mortar or concrete to become hard.

Apparatus:- Vicat apparatus, with needle and collar.

Procedure:- ① The cement paste is prepared as above and it is filled in the vicat mould.

② The needle with annular collar is attained to the moving rod of the vicat apparatus. The needle has a sharp point projecting in the centre with annular collar as shown in fig.

③ The needle is gently released. In the beginning the collar and needle may make an impression on the paste (test block). Repeat the procedure till the needle alone makes impression and collar fail to do so. Note down the time of the instant.

④ The time taken from the instant at which water is added to the instant and the needle alone makes impression on the paste (test block) is known as final setting time.

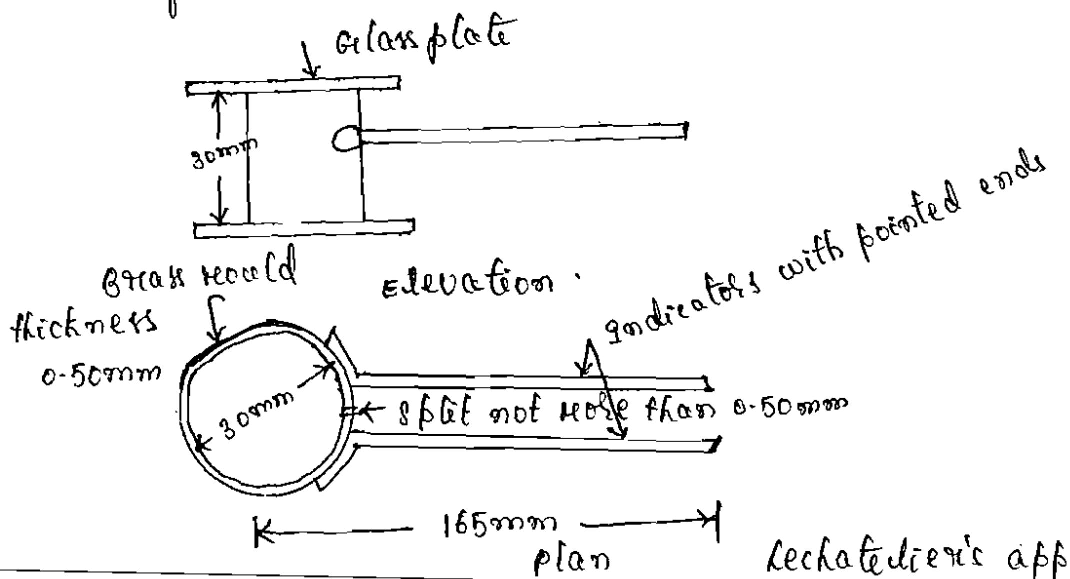
Note:- care shall be taken to clean the needle, if paste is stuck to the collar. Also release the needle every time at a new place on the surface of the paste.

Standard Results:- Initial and final setting times of different cements

Sl No	setting time	O.P.C	R.H.C	L.H.C
1.	Initial: not less than	30min	30min	60min
2.	Final: not less than	600min (10hrs)	600min (10hrs)	600min

→ soundness test:-

This test is conducted to find free lime in cement, which is not desirable. Lechatelier apparatus as shown in fig is used for conducting this test. It consists of a split brass mould of diameter 30mm and height 30mm. On either side of the split, there are two indicators, with pointed ends. The ends of indicators are 165mm from the centre of the mould.



Lechatelier's apparatus.

properly oiled Lechatelier mould is placed on a glass plate and is filled completely with a cement paste having 0.78 times the water required for standard consistency. It is then covered with another glass plate and a small weight is placed over it. Then the whole assembly is kept under water for 24 hours. The temperature of water should be between 24°c and 50°c. Note the distance between the indicator. Then place the mould again in the water and heat the assembly such that water reaches the boiling point in 30 minutes. Boil the water for one hour. The mould is removed from water and allowed to cool. The distance between the two readings indicates the expansion of the cement due to presence of unburnt lime. This value should not exceed 10mm.

→ Compressive strength test:-

for this 200gm of cement is mixed with 600gm of standard sand confaming confirming to IS 650-1966. After mixing thoroughly in dry condition for a minute distilled potable water [P/4]+3 percentage is added where p is the water required for the standard consistency. They are mixed with trowel for 3 to 4 minutes to get uniform mixture. The mix is placed in a cube mould of 70.6mm size (Area 5000mm²] kept on a steel plate and provided with 25mm standard steel rod 20 times with in 8 seconds. Then the mould is placed on a standard vibrating table that vibrates at a speed of 12000 ± 400 vibration per minute. A hopper is secured at the top and the remaining mortar is filled. The mould is vibrated for two minutes and hopper removed. The top is finished with a knife or with a trowel and levelled. After 24 ± 1 hour mould is removed and cube is placed under clean water for curing. After specified period cubes are tested in compression testing machine, keeping the specimen on its level edges. (11)

Average of three cubes is reported as crushing. The compressive strength at the end of 3 days should not be less than 11.5 N/mm² and that at the end of 7 days not less than 17.5 N/mm².

→ Concrete

plain concrete, commonly known as concrete, is an intimate mixture of binding material, fine aggregate, coarse aggregate and water. This can be easily moulded to desired shape and size before it looses plasticity and hardens. plain concrete is strong in compression but very week in tension. The tensile property is introduced in concrete by inducting different materials and this attempt has given rise to RCC, RBC, PSC, FRC cellular concrete and Ferro cement.

Major ingredients of concrete:-

① Binding material (like cement, lime, polymer)

② fine aggregate (sand)

③ coarse aggregates (crushed stone, jelly)

④ water.

A small quantity of admixtures like air entraining agents, water proofing agents, workability agents etc. may also be added to impart special properties to the plain concrete mixture.

Depending upon the proportion of ingredient, strength of concrete varies. It is possible to determine the proportion of the ingredients for a particu strength by mix design procedure. In the absence of mix design the ingredients are propotioned as 1:1:2, 1:1.5:3, 1:2:4, 1:3:6 and 1:4:8 which is the ratio of weights of cement to sand to coarse aggregate.

In proportioning of concrete it is kept in mind that voids in coar aggregates are filled with sand and the voids in sand are filled with cement paste.

proportions of ingredients usually adopted for various works are shown in table:-

s.no	proportion	nature of work
1.	1:1:2	for machine foundation, footings for steel columns and concreting under water.
2.	1:1.5:3	water tanks; shells and folded plates for other water retaining structures.
3.	1:2:4	commonly used for reinforced concrete works like beams, slabs, tunnel linin bridges.
4.	1:3:6	piers, abutments, concrete walls, sill of windows, floors.
5.	1:4:8	mass concretes like dam, foundation course for walls, for making concre blocks.

→ Various ingradients of cement concrete and their importance. (1)

cement:- cement is the binding material. After addition of water it hydrates and binds aggregates and the surrounding surfaces like stone and bricks. Generally richer mix (with more cement) gives more strength. setting time starts after 30minutes and ends after 6hours. Hence concrete should be laid into mould before 30minutes of mixing of water and should not be subjected to any external forces till final setting takes place.

coarse aggregate:- coarse aggregate consists of crushed stones. It should be wellgraded and stones should be of igneous origin. They should be clean, sharp, angular and hard. They give mass to the concrete and prevent shrinkage of cement.

Fine aggregate:- fine aggregate consists of river sand. It prevents shrinkage of cement. when surrounded by cement it gains mobility enters the voids in coarse aggregates and binding of ingredients takes place. It adds density to concrete, since it fills the voids. Denser the concrete higher is its strength.

water:- water used for making concrete should be clean. It activates the hydration of cement and forms plastic mass. As it sets completel concrete becomes hard mass. water gives workability to concrete which makes means water makes it possible to mix the concrete with easy and place it in final position. More the water better is the workability. However excess water reduces the strength of concrete. To achieve required workability and at the same time good strength a water cement ratio of 0.4 to 0.45 is used, in case of machine mixing and water cement ratio of 0.5 to 0.6 is used for hand mixing.

→ uses of concrete:-

① As a bed concrete below column footings, wall footings, on wall at supports to beams.

② As sill concrete.

③ over the parapet walls as coping concrete.

④ for flagging the area around buildings.

⑤ for pavements.

⑥ for making building blocks.

However major use of concrete is as a major gradient of reinforced and prestressed concrete. Many structural elements like footings columns, beams, chejjas, lintels, roofs are made with RCC. cement concrete is used for making storage structures like water tanks, bins, silos, bunkers etc. Bridges, dams, ~~[illegible]~~ retaining walls are R.C.C structures in which concrete are the major ingredient.

Tests on concrete:-

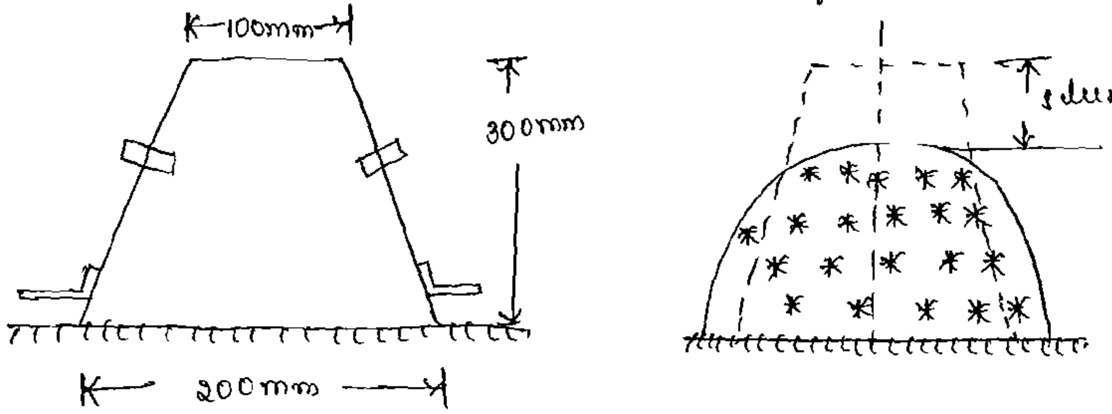
The following are some of the important tests conducted on concrete.

① slumptest

② compaction factor test

③ crushing strength test

① slumptest :- This test is conducted to determine the workabili of concrete. It needs a slumpcone for test as shown in fig.



slumpcone is a vessel in the shape of a frustum of a cone with diameter at bottom 200mm and 100mm at top and 300mm high. This cone is kept over a impervious platform and is filled with concrete in four layers. Each layer is tamped with a 16mm pointe rod for 25times. After filling completely the cone is gently pulled up. The decrease in the height of the concrete is called slump. Higher the slamp, more workable is the concrete.

② compaction factor test:- This is another test to identify the workabil of concrete. This test is ~~und~~ conducted in the laboratory. The test equipment consists of two hoppers and a cylinder fixed to a stand, the dimensions and the distances between the three vessels being standardized. vessel A and B are having hinged bottoms whereas

cylinder c is having fixed bottom. Top vessel A is filled with the concre
to be tested. As soon as it is filled, the hinged door is opened.
concrete is collected in vessel B. Then the hinged door of B is opene
to collect concrete in cylinder c. The concrete in cylinder c is weight
let it be w_1. Now the cylinder is again filled with the sample of
concrete in 50mm layers which is compacted by rammer and vibra
Then the weight of compacted concrete is determined. Let the weight
be w_2. The ratio w_1/w_2 is termed as compaction factor.

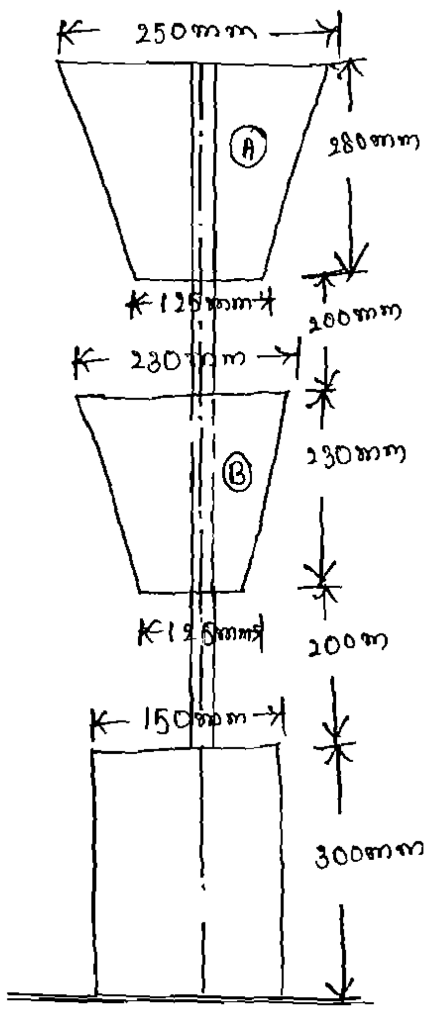


figure compaction factor test

then the hinged do

③ crushing strength test :- cement, fine aggregate and coarse aggrega (up to 38mm) to be used for making concrete are brought to room temperature (preferably 27 ± 3°c) before commencing the test

The ingredients are weighed in the ratio to be used in the field and are mixed by hand mixing or by machine mixing. First the cement and sand are mixed thoroughly till a uniform colour is achieved. The coarse aggregate are then added and mixed till these are distributed uniformly through out the mix. The water is then added and the entire batch is then mixed untill the concrete appears to be homogeneous and has the desired consistency.

The test specimens recommended are 150 X 150 X 150mm cubes or cylinders of 150mm diameter and 300mm height. The mixed concrete is filled in to the moulds in layers of 50mm to achieve full compaction. Each layer of mix so placed is tamped with bar, 16mm in diameter and 600mm long, 35 times or with a vibrator. The test specimens are stored at a temperature of 27 ± 3°C and at 90 percent humidity for 24 ± 1/2 hour from the time of addition of water to the dry ingredients. After this period the specimens are removed from the moulds and placed in water and kept there until taken out just prior to test. Normally the recognized age of test of specimens is 7 and 28 days.

Atleast three specimens, preferably ~~with~~ from different batches are tested at each age (selected). The specimen should be tested immedia after taking out them from water with surface water wipped off.

The specimen is placed between the platens of the compression testing machine with the care that the axis of specimen is aligned with the centre of thrust of the spherically seated platen. The compression test machine should be able to apply gradual load of 14 N/mm^2/minute, until the specimen is crushed.

$$\text{compressive strength} = \frac{\text{Maximum load}}{\text{cross sectional area}}$$

The average of the three values is taken as the compressive strength of concrete of the batch, provide the individual variation is not more than ± 15 percent of the average