Limes

Building Construction Material

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Limes

Introduction

- **Cementing material:** The material which has the capacity of **holding structural units** (like bricks, stones, aggregate)
- **Examples:** ***Lime, natural cements, gypsum, Portland cement***
- Lime is an oxide of **calcium, CaO**
- **Uses:** ***Ordinary buildings, massive monuments, palaces, forts***
- At present, the cement has replaced lime to a great extent.
- But at places where lime is locally available and when there is acute shortage of cement, lime will be used as a binding material.
- ***As a Reliable and economical cementing material***.

Lime : As a Reliable and economical cementing material

Some Important Definitions

(1) Calcination : The heating to redness in contact with air is known as the calcination.

(2) **Hydraulicity :** It is the property of lime by which it sets or hardens in damp places, water or thick masonry walls where there is no free circulation of air.

(3) **Lime :** Due to calcination of limestone, the moisture and carbon dioxide are removed from it. The product which remains thereafter is known as the lime. It chemical composition is (CaO) oxide of Calcium.

$CaCO_3$	=	CaO	+	CO_2
(Limestone)		(Lime)		(Carbon Dioxide)

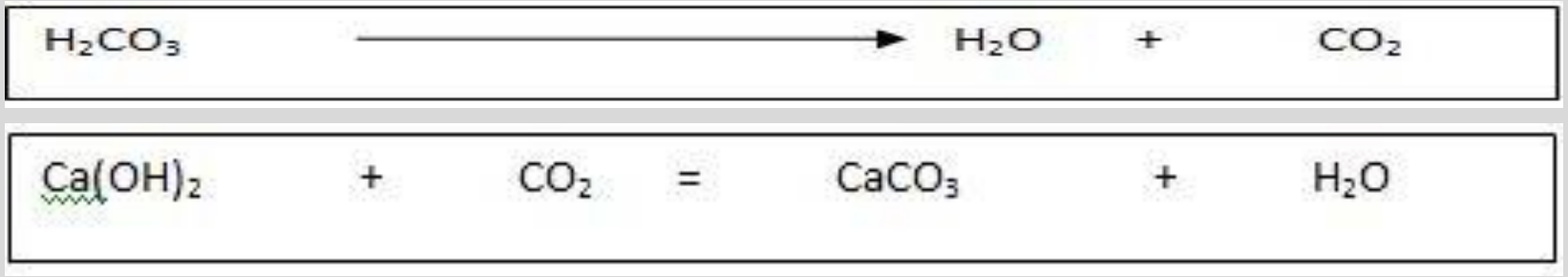
(4) Quick Lime : The lime in which is obtained by the calcination of comparatively pure limestone is known as the quick lime or caustic lime. Its chemical composition is (CaO) oxide of calcium and it has great affinity for moisture. The quick lime as it comes out from kilns is known as the lump lime.

(5) **Setting :** The process of hardening of lime after it has been converted into paste form is known as the setting. It is quite different from mere drying. In case of drying, the water evaporates only and no setting action takes place.

(6) **Slaked Lime :** The product obtained by slaking of quick lime is known as slaked lime or hydrate of lime. It is in the form of white powder and its chemical composition is Ca(OH)2 or hydrated oxide of calcium.

CaO	+	H_2O	⟶	Ca(OH)2	+	Heat
(Quick Lime)		(Water)		(Hydrated Lime)		

- The rate of slaking is affected by the size of lime lumps and temperature. It accelerates with the rise in temperature. It can be carried out very speedily by steam under pressure in closed drums.
- The slaked lime should always be used as fresh as possible because it has the tendency to absorb carbonic acid from the atmosphere in presence of moisture and to form particles of carbonate of lime



- The slaked lime is thus converted into carbonate of lime and such slaked lime becomes useless because it loses its setting property. The slaked lime should therefore be not kept in a damp place.

(7) Slaking : When water is added to the quick lime in sufficient quantity, a chemical reaction takes place. Due to this chemical reaction, the quick lime cracks, swells and falls into a powder form which is the calcium hydrate Ca(OH)2 and it is known as the hydrated lime. This process is known as the slaking.

Sources Of Lime :

The lime is not usually available in nature in free state. It is procured by burning one of the following materials :

(i) Limestone from the stone hills
(ii) Boulders of limestones from the beds of old rivers
(iii) Kankar found below the ground, and
(iv) Shells of sea animals

It may be noted that white chalk is pure limestone and kankar is an impure limestone.

White Chalk

Kankar

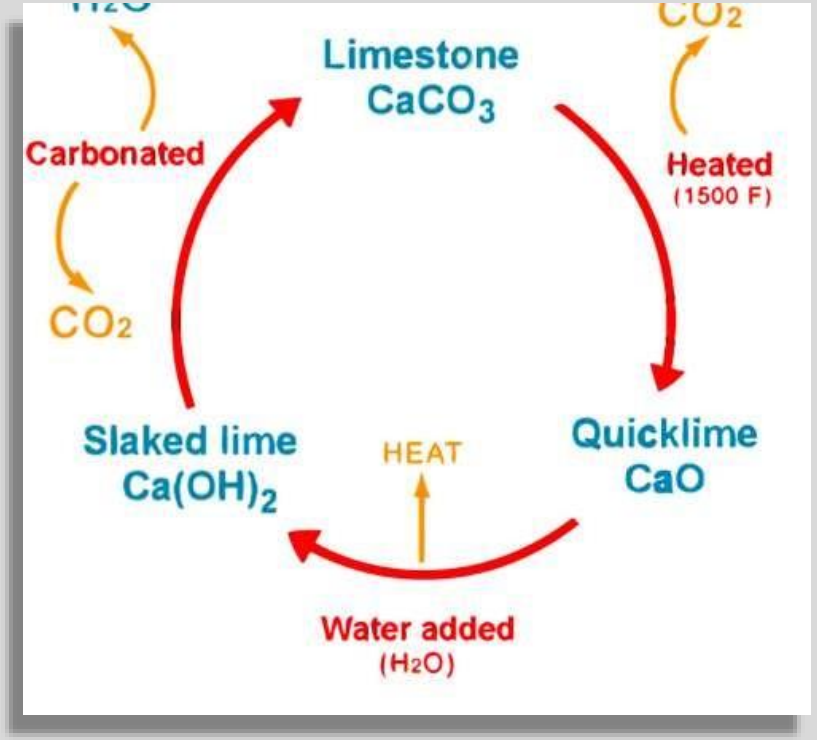
Classification of Limes

- **Lime is available in the market in three main types** which are Fat lime, Hydraulic Lime and Poor Lime.
- **Classification:** based on calcination of limestones

i) Fat lime

ii) Hydraulic lime

iii) Poor Lime



COMPARISON BETWEEN FAT LIME AND HYDRAULIC LIME

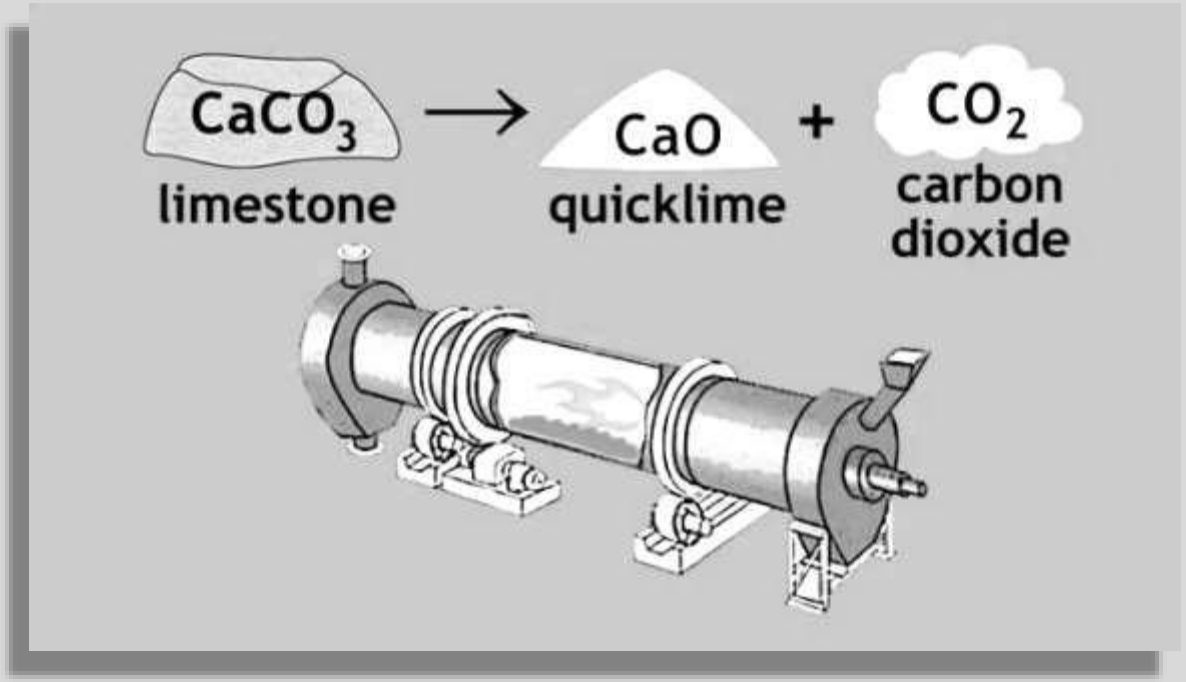
No.	Item	Fat lime	Hydraulic lime
1.	Composition	It is obtained from comparatively pure carbonate of lime containing only 5 per cent of clayey impurities.	It is obtained from limestones containing clay to the extent of about 5 to 30 per cent and some amount of ferrous oxide.
2.	Slaking action	It slakes vigorously. Its volume is increased to about 2 to 2½ times the volume of quick lime. The slaking is accompanied by sound and heat.	It slakes slowly. Its volume is slightly increased. The slaking is not accompanied by sound or heat.
3.	Setting action	It sets slowly in presence of air. It absorbs carbon dioxide from atmosphere and forms calcium carbonate.	It sets under water. It combines with water and forms crystals of hydrated tricalcium aluminate and dicalcium silicate.
4.	Hydraulicity	It does not possess hydraulic property.	It possesses hydraulic property.
5.	Colour	It is perfectly white in colour.	Its colour is not so white as fat lime.
6.	Strength	It is not very strong. Hence it cannot be used where strength is required.	It is strong and can therefore be adopted where strength is required.
7.	Uses	It is used for plastering, white-washing, etc. and for preparing mortar with sand or surkhi.	It is used for preparing mortar for thick walls, damp places, etc. Extreme care is required to prepare mortar of this lime for plaster work.

(3) Poor Lime : This lime is also known as the impure lime or lean lime. It contains more than 30% of clay. It slakes very slowly. It forms a thin paste with water. It does not dissolve in water though it is frequently changed. It sets or hardens very slowly. It has poor binding properties and its colour is muddy white.

This lime makes a very poor mortar. Such mortar can be used for inferior(low quality) type of work or at places where good lime is not available.

Quicklime


Quicklime
is a caustic white alkali with the chemical name calcium oxide.
CALCIUM OXIDE or QUICKLIME


$CaCO_3$
limestone
CaO
quicklime
+
CO_2
carbon dioxide

Hydraulic Lime

I.S. Specifications of Lime

According to **BIS:712-1984(3rd revision)** building limes are classified under six categories :

Class-A : **Eminently Hydraulic Lime**	**Can be used for structural works such as arches domes etc.**
Class-B : **Semi-Hydraulic Lime**	**Can be used for constructing masonry**
Class-C : **Fat Lime**	**Can be used for Finishing Coat in Plastering , white washing, etc. or used for masonry mortar with addition of pozzolanic material**
Class-D : **magnesium / dolomite Lime**	**Can be used for Finishing Coat in Plastering and white washing.**
Class-E : **Kankar Lime**	**Produce by burning Lime Nodules (found in soil like black cotton soils contain silica) , it can be use for masonry mortar**
Class-F : **Siliceous dolomite Lime**	**It is used generally for undercoat and finishing coat of plaster**

Uses Of Lime

- **Uses of lime: Lime is very useful material that finds extensive applications in building construction, industry and agriculture.**

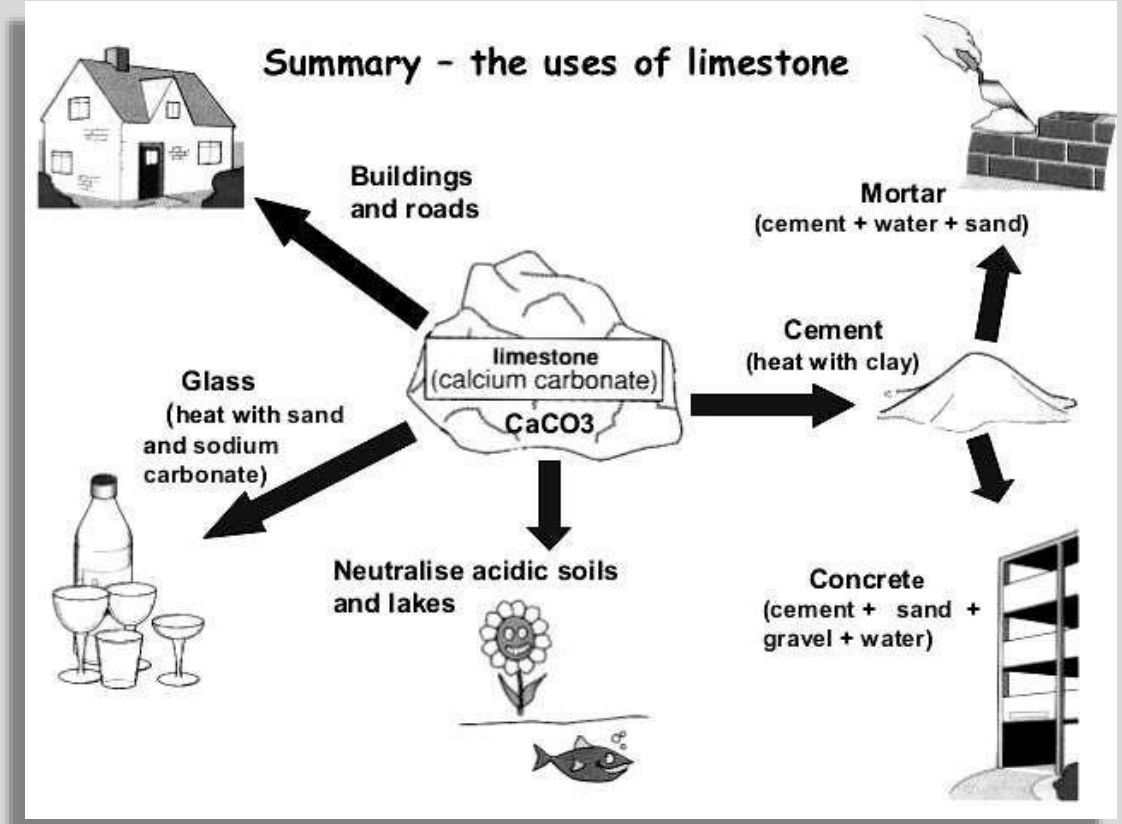
(a) As a construction material: Lime was used as main binding material in all types of construction till 19th century. Even now lime can compete with Portland Cement in many types of construction.

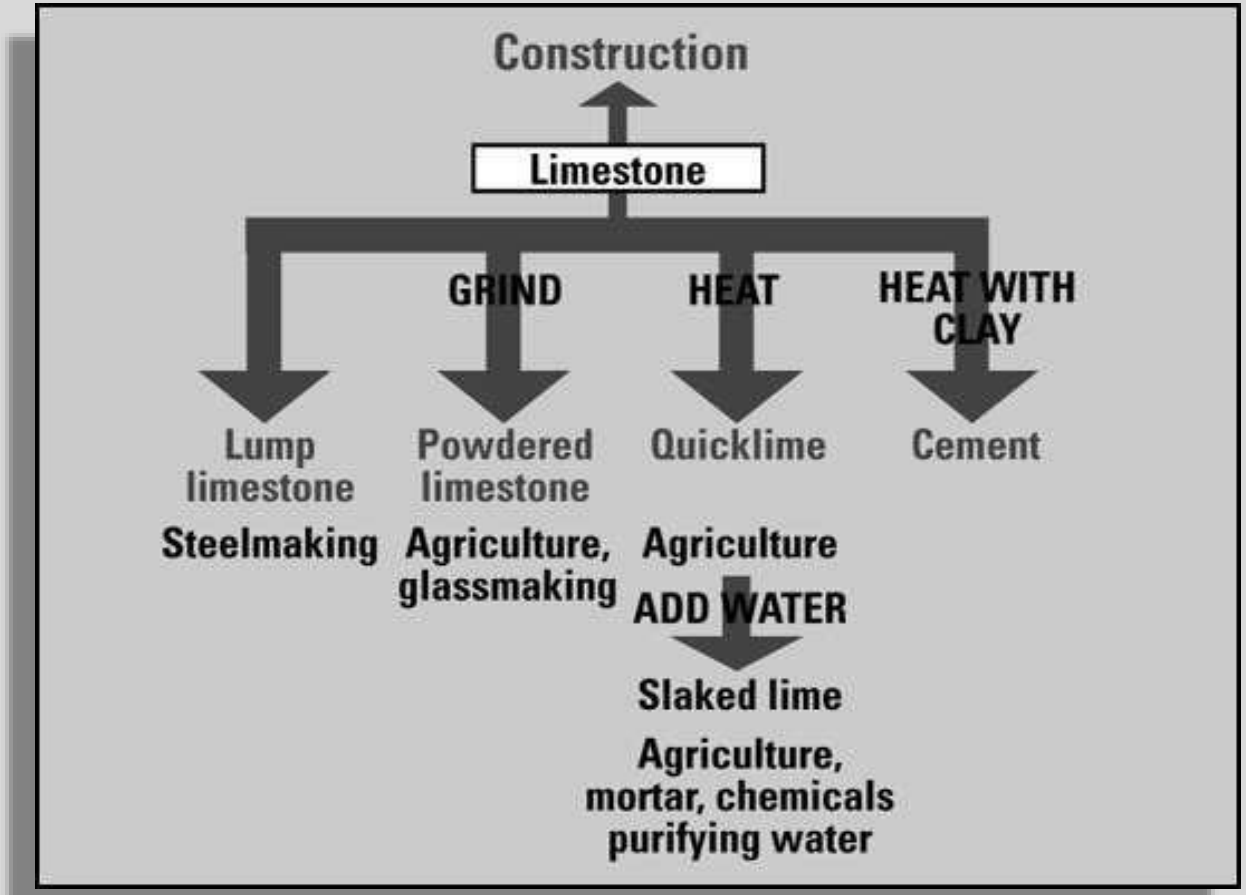
- *as a mortar (lime-mortar) mixed with sand or surkhi.*
- *as a plaster*
- *as a whitewash which gives sparking white finish at a very low cost*
- *as a lime-concrete similar to cement concrete made by mixing lime, sand and coarse aggregate in proper proportions*
- *as sand-lime bricks which are quite popular in many countries*

Uses Of Lime


Traditional
LIME MORTAR
Mike Wye & Associates
Tel/Fax: 01409-281-644
www.mikewye.co.uk
HEALTH & SAFETY WARNING

Uses Of Lime


Summary – the uses of limestone
Buildings and roads
Mortar (cement + water + sand)
limestone (calcium carbonate)
CaCO3
Cement (heat with clay)
Glass (heat with sand and sodium carbonate)
Neutralise acidic soils and lakes
Concrete (cement + sand + gravel + water)


Construction
Limestone
GRIND
HEAT
HEAT WITH CLAY
Lump limestone
Powdered limestone
Quicklime
Cement
Steelmaking
Agriculture, glassmaking
Agriculture
ADD WATER
Slaked lime
Agriculture, mortar, chemicals purifying water

Uses Of Lime

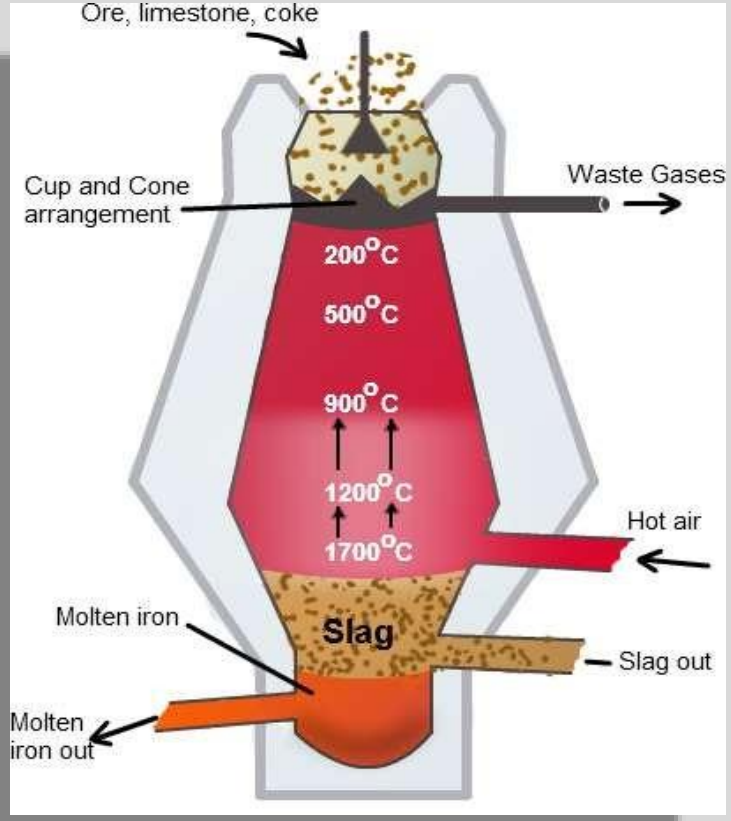
(b) As an industrial material: In industries lime find use as

- **A flux(chemical cleaning agent/ purifying agent/ flowing agent) in the metallurgical industry**
- as a **refractory material (Has resistant to decomposition of heat, pressure or chemical attack and retains strength and form at high temperatures)** for lining metallurgical furnaces
- as a raw material for the **manufacture of glass**

(c) An agricultural input:

- **Lime is used to to improve productive qualities of soil** and added to the poor soils to enrich their lime content
- Lime has also been used for soil stabilization.

Uses Of Lime


Ore, limestone, coke
Cup and Cone arrangement
Waste Gases
200°C
500°C
900°C
1200°C
1700°C
Hot air
Molten iron
Slag
Slag out
Molten iron out


Soda-lime glass

Manufacturing Of Fat Lime

- **The essential raw material for the manufacturing of quick lime is a rock called LIMESTONE $CaCO_3$.**
- Three distinct operations are involved in the manufacture of fat lime :

1. Collection of lime stones
2. Calcination of lime stones
3. Slaking of burnt lime

1. Collection of lime stones : Limestone is a sedimentary rock which occurs in nature in good abundance forming hill ranges, plateaus. These are of required quality are collected at site of work. For fat lime, the percentage of impurities in lime stones should not exceed 5%. It is desirable to use comparatively pure carbonate of lime in the manufacturing process of fat lime.

Manufacture Of Fat Lime

2. Calcinations (process of burning): Lime is manufactured by a process of burning or calcinations of limestone in suitable types of kilns. The term calcinations signifies

- "Heating the material at red heat in the presence of air till it decomposes"

Lime stone dissociates when heated at 880º C into its principal constituents; Calcium oxide and carbon dioxide, as per above reaction which is reversible.

$$CaCO_3 \ (880^0\,C) \longleftrightarrow CaO + CO_2$$

- It is essential that, all the carbon dioxide produced during the reaction is removed quickly from the kiln.
- The fuel required for calcination of lime stones may consist of charcoal, coal, firewood or coal ashes.

Calcinations

Calcination

➢ $CaCO_3 \longrightarrow CaO + CO_2$ (> 900°C)

"quick lime"

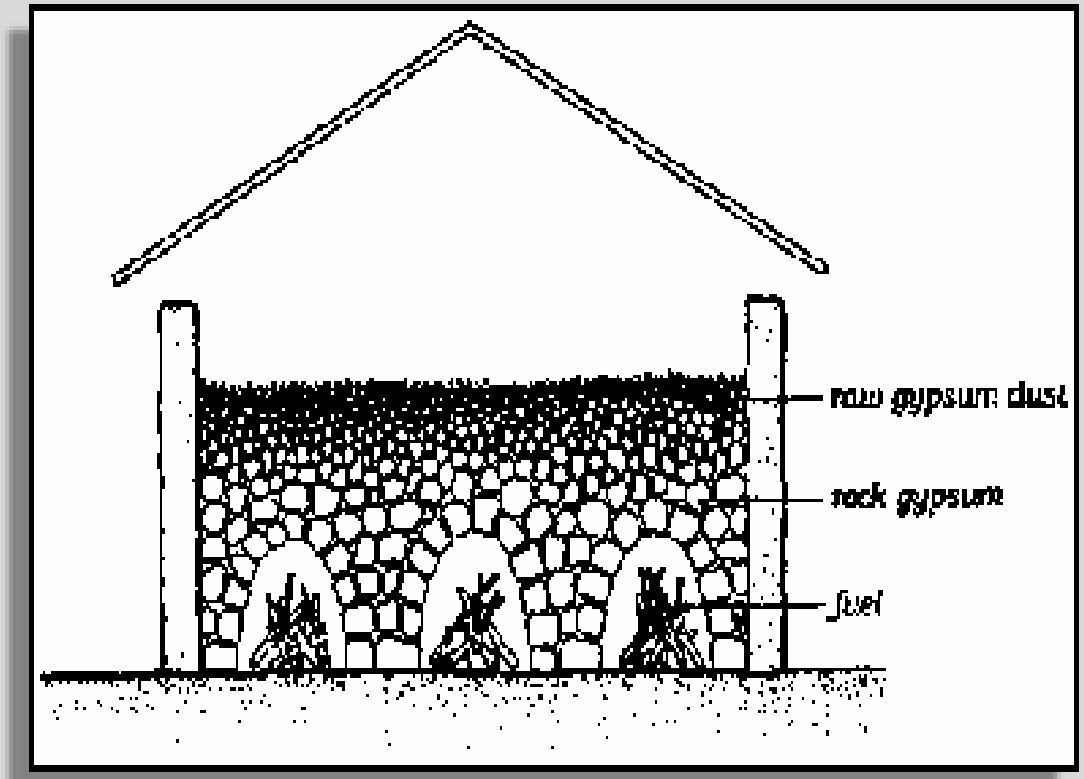
	atomic weight (g/mol)
Ca	40.078
O	15.999
C	12.011

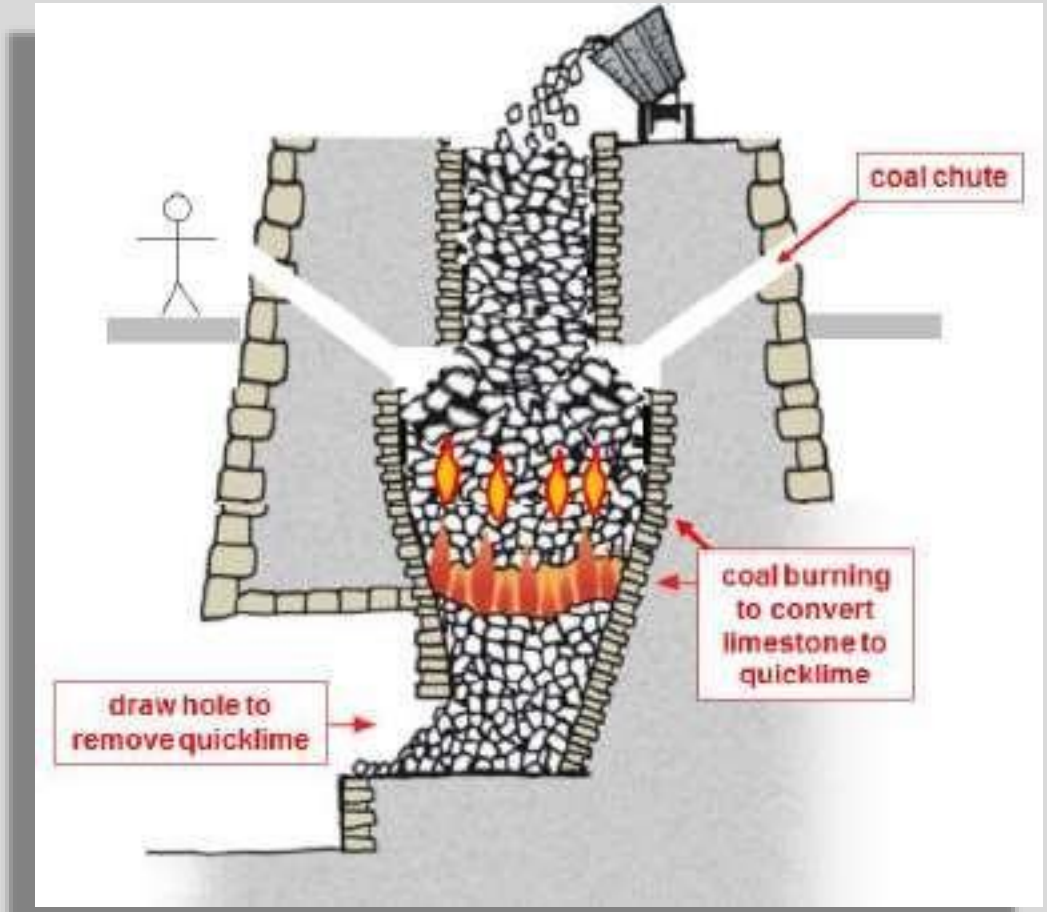
- Calcination is carried out in kilns:
  - Intermittent
  - Continuous
  - Rotary
  - Reactor

Manufacture Of Fat Lime

- ***The Burning of Limestone is carried out either in clamps or in kilns.***
- **Clamps are temporary, make shift arrangements** for burning in an ordinary manner and at a much lower cost.
- **Kilns are, however permanent structures** build to carry out the burning operations at a regular intervals or on continuous basis. They may be of intermittent type or continuous type.

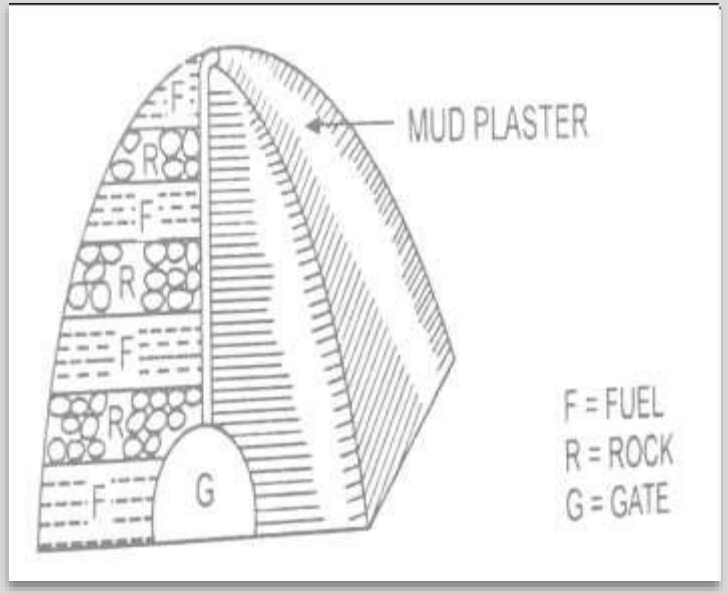
Clamps & Kilns





Manufacture Of Fat Lime – Clamp Burning

- **It is a common method for obtaining small supplies of quick lime.**
- **No permanent construction is needed.** The ground is levelled and cleaned. The limestone and fuel are placed in alternate layers, if fuel is wood.
- **If coal or charcoal is used as fuel, it is mixed with the limestone instead of stacking in separate layers.** The whole heap is covered with mud plaster[To preserve as much heat as possible] and small holes are left for escape of carbon dioxide.



Clamp Burning

Manufacture Of Fat Lime – Clamp Burning

- **Clamp is ignited from the base and allowed to keep on burning for 2-3 days.** Burning is discontinued when blue flame disappears{*It indicates the completion of the burning of lime*} at the top and it is allowed to cool for 2-3 days.
- **It is then dismantled. Limestone gets disintegrated into small pieces of small lumps of CaO or lime.** Such lumps are separated from the ash by hand picking.
- **Clamp burning is a quick and cheap method for obtaining ordinary type of lime and not suitable for large supplies of fat lime of good quality because;**
- The quantity of fuel required is more and hence it is practised where limestone and fuel are abundant.
- **Some stones may be over burnt and some may be under burnt resulting** in wastage of raw materials; Burning is not uniform.
- **There is considerable Wastage of heat generated by burning of fuel.** Some of it escapes from frequent cracking of the plaster on getting heated. Thus this method is not suitable method of producing fat lime on a commercial scale.

Manufacture Of Fat Lime – Kiln Burning

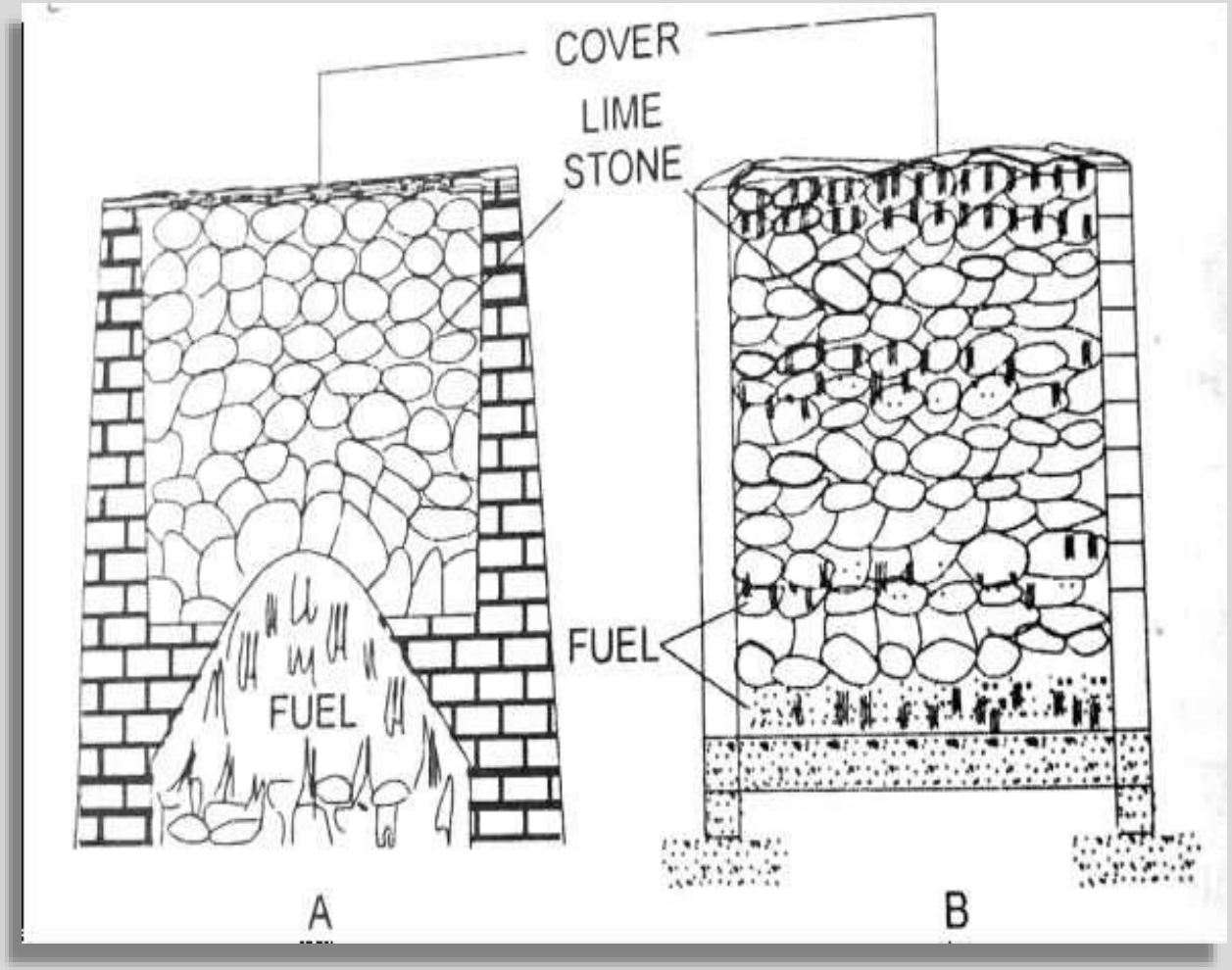
- **Most of the Commercial lime is manufactured by burning limestone in kilns, they are Permanent structures, kilns used for manufacturing lime are of great variety and different designs**.
- In principle, however they are either **Batch type (intermittent) kiln / Continuous kiln.** In the first type of kiln however kilns have to be cooled every time after burning a batch of limestone. The continuous type however are kept in operation all the time unless they are required to be stopped for repair. Further, a kiln may be of mixed type or separate type design.
- **Mixed feed (flame type) kiln** – fuel and limestone are in a mixed together batch, burnt lime is obtained mixed with ash and has to be separated from it.
- **Separate feed (flare type) kiln** – fuel and limestone are not in contact with each other, fuel is burnt separately, hot gases are allowed to heat limestone and lime is free from ash.

Manufacture Of Fat Lime – Kiln Burning

(1) Batch type (intermittent) kiln: There are two important types of intermittent kilns are present.

Intermittent flame kiln :

- This is a intermittent kiln in which alternate layers of limestone and fuel are arranged.
- The horizontal and vertical flues are suitable formed and top of kiln is covered with un-burnt material.
- The kiln is ignited from bottom and limestone are allowed to burn for about 3 days or so.
- The kiln is cooled and unloaded.
- The process is then repeated.



Intermittent Kilns

Manufacture Of Fat Lime – Kiln Burning

Intermittent Flare kiln : In this type of intermittent kiln the fuel is not allowed to come into contact with limestone.

- A rough arch of selected big pieces of limestone is formed and smaller pieces of limestone are packed over this arch.
- The fuel is placed below the arch and when it is ignited, only flame comes into contact with limestone.
- When limestone are sufficiently burnt, the kiln is cooled and unloaded.
- The process is then repeated.
- This type of kiln is easy to manage.
- The flare kiln produces lime of better quality because the limestone are not in contact with fuel and the finished product is not mixed with ashes.

Note : There is a considerable wastage of time in intermittent kilns as every operation includes loading, burning, cooling and unloading. The supply of lime is also not continuously guaranteed. Hence such kilns are used to manufacture lime on moderate scale.

Manufacture Of Fat Lime – Kiln Burning

(2) Continuous kiln:

- **The essential feature of a continuous lime kiln is that while It is charged regularly from one end with the raw material and the end product is taken out regularly from the other end.**
- As such there is No need to cool the kiln every time after burning a batch of limestone.
- Naturally its Rate of production of lime is higher than other types of kilns.
- **Continuous kilns are of various Types such as – shaft kiln, rotary kiln, circular kiln etc of these the shaft kiln are most popular. They are made in different design shape and sizes.**

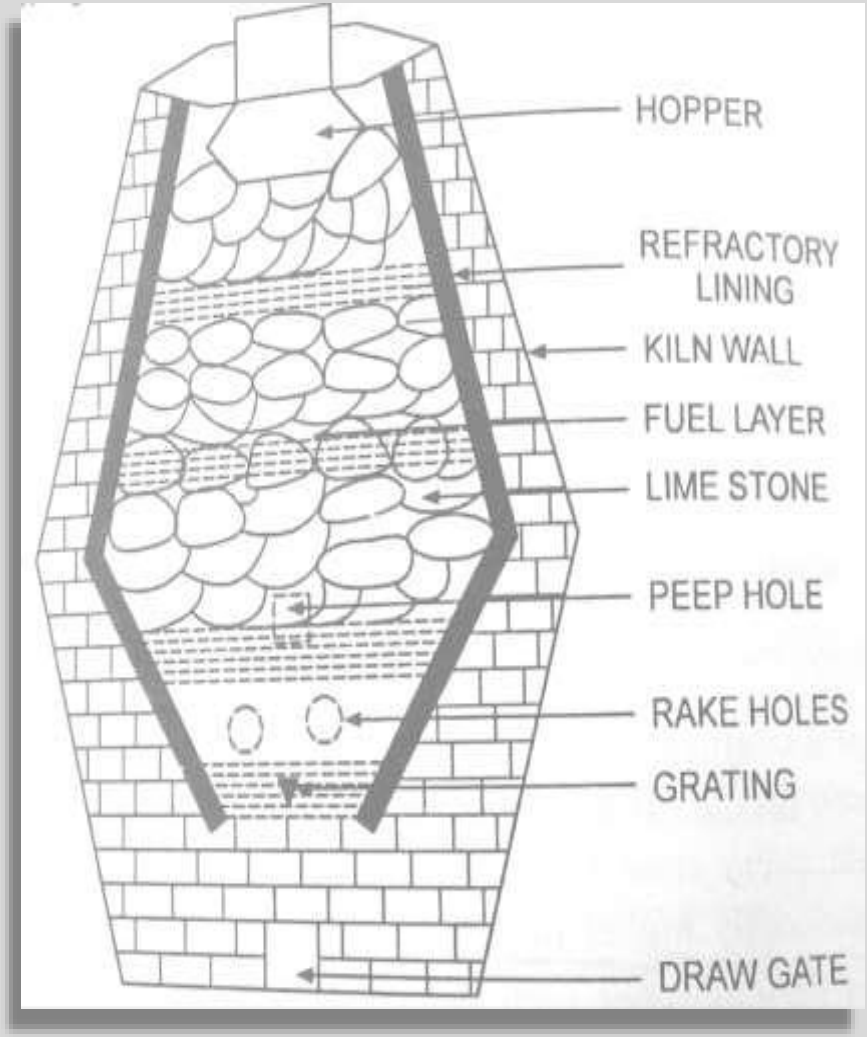
Manufacture Of Fat Lime – Kiln Burning

(A)Mixed feed (flame type) continuous kiln:

- **It may be constructed Partly underground and partly over ground**, the kiln consists of a shaft or a cylinder of suitable dimensions, the essential features of which are,
- **Diameter** – in middle[2.30m] greatest, at top[1.80m] intermediate and at bottom[1.40m] least
- **Variation in diameter accumulate large amount of limestone in the central part as it is hottest zone and ensures complete calcinations.[or simply to accommodate hot gases of combustion]**
- The shaft is lined internally with refractory bricks
- **A grating plate is at the base of the shaft, which is full of holes to allow the burnt lime pieces to fall down in the collecting chamber.** The kiln is provided with a hopper type of arrangement at the top for loading the charge and also draw gates at the bottom for withdrawing the lime after it is cooled. The body of kiln is provided with opening in the lower region for supply of fresh air. It is also provided with observation holes in the middle region for keeping an eye on the reactions. Openings are provided for leading the wastage out of the kiln.

Manufacture Of Fat Lime – Kiln Burning

- **At top hopper type arrangement for loading the charge and at bottom draw-gates are provided for withdrawing the lime after cooling.**
- **At lower region opening is provided for supply of fresh air,** at middle region holes for observation of the reaction and at top openings is for leading the waste gases out of kiln



Continuous Flame-type: Mixed Feed Kiln

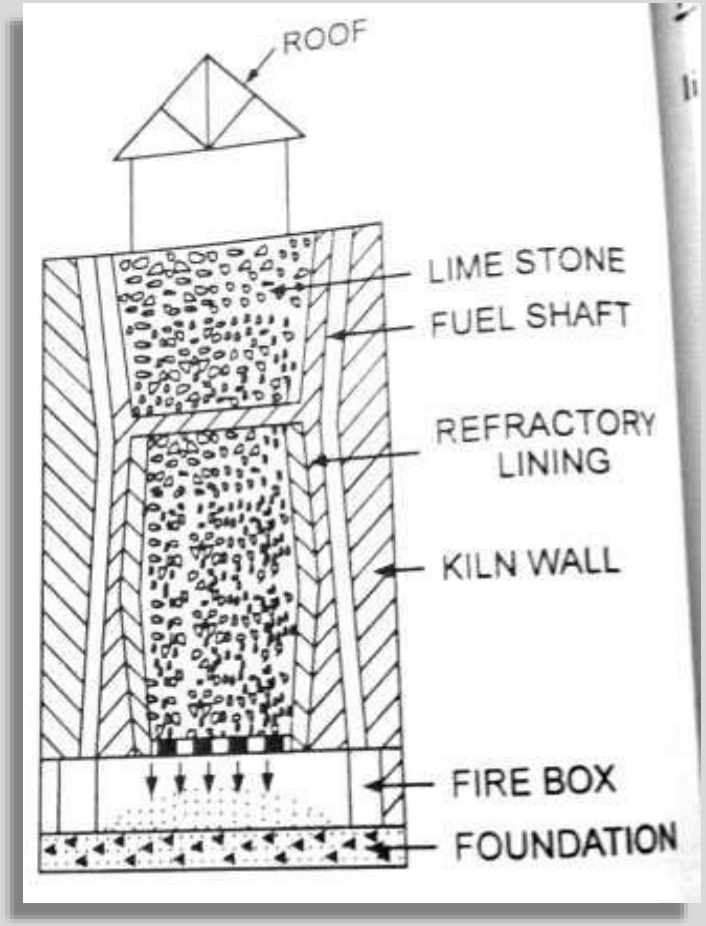
Manufacture Of Fat Lime – Kiln Burning

- **Alternate layers of limestone and fuel is placed and then ignited through burn holes.**
- **Main calcinations reaction takes place in the central burning zone of the kiln.**
- At uppermost zone charge is heated up which helps in its quicker calcinations as it slides down.
- When limestone in the burning zone is completely converted to lime, it slides down and falls into collecting chamber.
- Hot lime dropped in the basal zone is first cooled by introducing fresh air.
- The charging and emptying operations are continued in this manner in a regular sequence

Manufacture Of Fat Lime – Kiln Burning

(B) Separate feed (flare type) continuous kiln:

- In any case, there is no contact between the fuel and the limestone.
- This kiln consists of two sections – upper and lower.
- The upper section serves as a storage of limestones.
- The lower portion is provided with fire – brick lining.
- While starting the kiln, a small quantity of fuel is mixed with limestone and ignited.
- The fuel is then fed through shafts around the upper and lower sections of kiln.
- The feeding of limestones is done from opening at top.
- The removal of calcined material is done through a grating placed at the bottom of kiln. A roof is provided at the top to protect the kiln.
- There is considerable saving of time and fuel in case of continuous kilns, but the initial cost is high. Hence there kilns are adopted to manufacture lime on large scale.



Continuous Flare-type: Separate Feed Kiln

Manufacture Of Fat Lime – Kiln Burning

(3) Slaking of burnt lime : The quick lime which is obtained by burning of limestones slakes when exposed to the atmosphere. This is known as the natural slaking or air slaking and it is a very slow process. Hence the slaking is achieved by adding water to quick lime. Following are the two methods of slaking

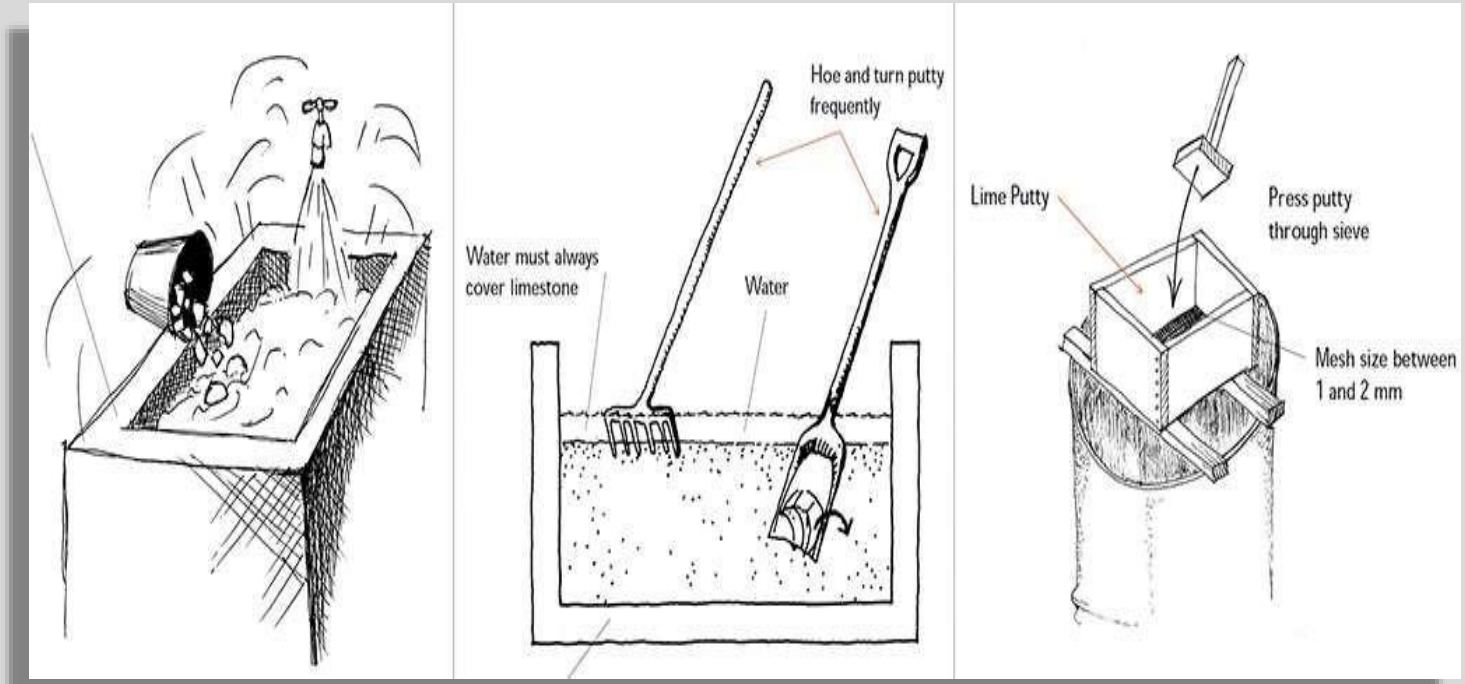
(i) Slaking to paste

(ii) Slaking to powder

A. Slaking to paste : In this method, the quick lime is spread in a layer of 150 mm depth in a wooden or masonry basin. The water in sufficient quantity is then added so as to submerge quick lime. It is found that the quantity of water required is about 2 ½ to 3 times the volume of quick lime. The excess water retards slaking and little water results in unsatisfactory slaking.

The water should be added at a time and it should not be added after the temperature has risen. The basin is covered with wooden planks to preserve heat and to ensure proper slaking of the entire mass of quick lime. The stirring is not necessary and slaking is completed in about ten minutes or so.

Tank Slaking (Making Lime Putty)



B. Slaking to powder : In this method, the quick lime is slaked to powder form. This may be achieved in one of the following two ways :

(a) The quick lime broken into pieces of size not more than 50 mm. It is then carried in a basket and the basket is immersed in water for few seconds. It is then taken out and thrown on a wooden or masonry platform in a heap form. The quick lime crumbles and falls as powder form. The period for which basket is to be immersed in water is to be determined from experience.

(b) In this arrangement, the quick lime is spread in layer of 150 mm depth on a wooden or masonry platform. The water is then sprinkled over this layer from a water – can or vessel fitted with a rose or perforated nozzle. The quick lime swells, crumbles and falls as powder form. This method is generally used to slake quick lime obtained from the shells.

It is to be noted that over – burnt or under – burnt limestones do not slake easily. Hence such undesirable pieces should be removed before slaking. It is also necessary to convert all lumps into powder or pulp form. It is observed that one part of fat quick lime is converted into about 1 ½ parts in paste form and about two parts in powder form.

Manufacture Of Natural Hydraulic Lime

- Following *three* distinct operations are involved in the manufacture of natural hydraulic lime :

(1) Collection of kankar
(2) Calcination of kankar
(3) Slaking and of burnt lime

Collection of kankar : The kankar is an impure limestone and it is used for manufacturing natural hydraulic lime. The kankar is available in two forms, namely, nodules and block.

The nodules are found either on surface of ground or slightly below ground level.

The nodules of kankar are easy to collect and kankar in nodular form is considered as superior material for manufacturing the natural hydraulic lime for following reasons :

(i) It can withstand heat and rain without disintegration
(ii) It contains higher percentage of clay and hence it possess better hydraulic properties.

The blocks of kankar are found from the underground strata below or on or near the banks of rivers or streams. The thickness of blocks is usually 50 mm to 300 mm.

The nodules or blocks of kankar are quarried with the help of pick – axes and crowbars. Such kankar is then cleaned of mud or earth and converted into suitable sizes.

(2) Calcination of kankar : The calcination or burning of kankar to bright red heat is done either in clamps or kilns as in the case of manufacture of fat lime.

(3) Slaking of burnt lime : The slaking of hydraulic lime occurs very slowly. Hence the quick lime is first ground dry before water is added for slaking.

Manufacture Of Hydraulic Lime

Differences in slaking of fat lime and hydraulic lime

- In case of fat lime, the required quantity of water for slaking is added at a time. In case of hydraulic lime, the water is added gradually to cause thorough slaking.
- One part of fat quick lime, when slaked, is converted into about 1 ½ parts in paste form and 2 parts in powder form. One part of hydraulic quick lime, when slaked, is converted into about 1 part in paste form and 1 ½ parts in powder form.
- The quantity of water required to slake fat lime is more than that required for hydraulic lime.
- The time taken by fat lime to slake is about 3 to 4 hours and that by hydraulic lime is about 12 to 48 hours.

Handling And Storage Of Lime

- **<u>Handling and storage of lime:</u> Lime in its raw form requires careful handling to avoid accidents and losses**

(i) Quick lime – should be protected from water, as it will start getting hydrated with the evolution of heat that can cause burn injuries of various serious nature.

- **If it is stored in wooden barrels and it comes in contact with water,** so much heat may be evolved to burn barrel, store house or the wagons/trucks in which it is being transported.

(ii) Fat lime – must be protected from direct contact with atmospheric moisture and carbon dioxide which starts setting and gets converted to a useless hard material having no binding properties.

- It is therefore required to convert the lime into lime putty as soon as possible and stored into a compact heat covered with a thick layer of lime dust which saves the attack of moist air.

(iii) Hydraulic lime – safer in transport and can be stored for longer period as compared to fat lime.

Handling And Storage Of Lime

- **Precautions to handle lime:**

- The lime dust causes irritation and hence the workers handling lime should be provided with goggles and respirators. The lime also causes skin burns, especially if the skin is moist. It is therefore advisable to provide rubber gloves, gum boots and skin protective cream to the workers likely to get skin burns.
- After handling lime, the workers should be instructed to wash the exposed portions of the body with abundant fresh water. Similarly the workers handling milk of lime, which is hot. Should be advised to oil their skin daily to avoid skin burns.

Tests For Lime

Building lime required to satisfy a number of tests before it is approved for use in construction work. Various chemical tests conducted on laboratory are :

1.Chemical Composition: Lime is tested To determine ratio of different components such as **CaO, MgO, SiO_2, AlO_2** and iron oxides.

- The limits of component should be as per **IS:712-1973**

2. Fineness: To determine the fineness of grain size by sieve analysis

- The residue is weighed after the test and should not exceeds the specified limits.

Tests For Lime

3. Soundness: It is defined as The capacity of lime to resist expansion on setting

- **It is tested with the help of Le Chatelier apparatus.**
- Lime is mixed with sand and water and filled in mould of the apparatus.
- The distance between the indicator points is noted and after one hour placed in a steam boiler for three hours.
- After the boiling action, the distance between the indicators is noted once again.
- Difference between the two readings gives a measure of soundness which should be within prescribed limit.

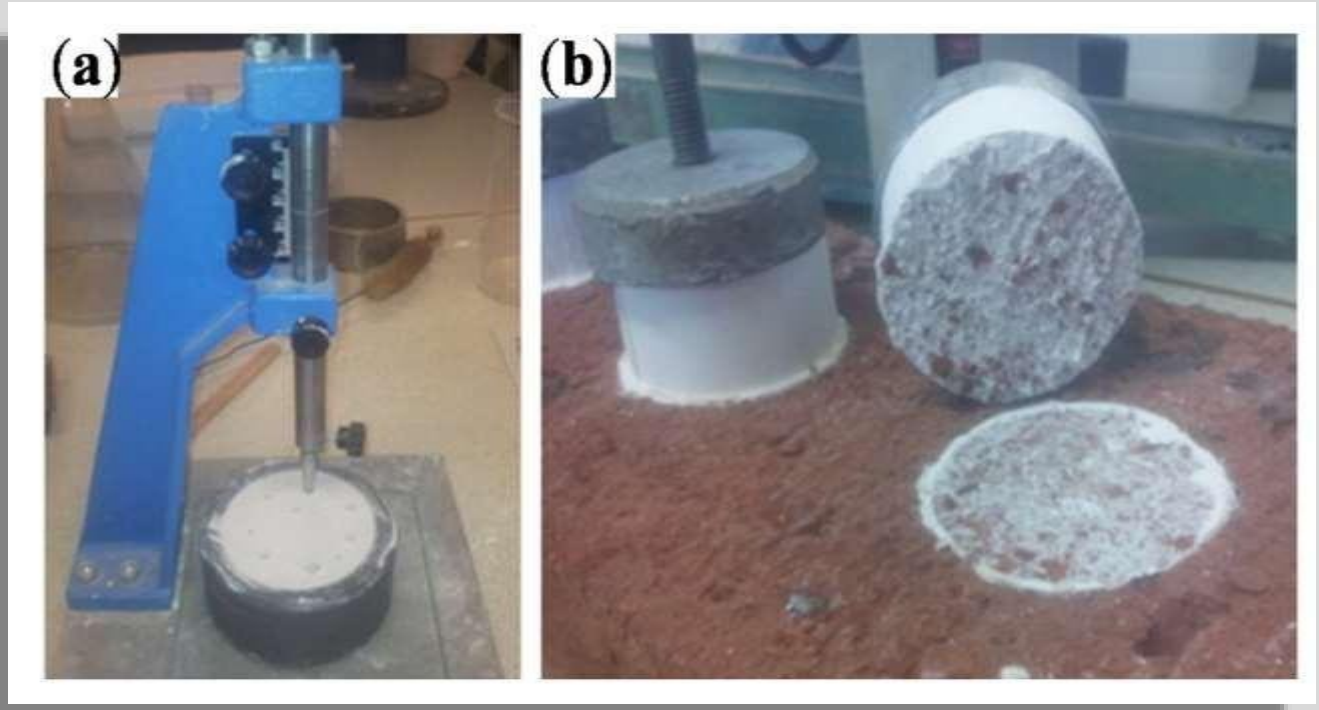
Soundness of Lime

Tests For Lime

4. Setting Time: The time that elapses between the preparing of lime paste of standard consistency and setting of the same paste after it has been filled in a standard mould (Vicat Mould) to a minimum specified depth.

- **Initial setting time**: The time that elapses from the gauging to the penetration of the Vicat needle in the paste up to a specified depth – 35mm
- **Final setting time**: The time that elapses from the gauging to a time when Vicat needle can no more penetrate the paste (because it is already set) and makes only a mark on the surface.

Setting Time



Tests For Lime

5. Strength: Tested by preparing specimens of standard sand-lime mortar,

- **For compressive strength** – average of 12 specimens, tested on standard testing machine on specimens taken after 14 days and 28 days
- **For transverse strength** – average of 6 specimens, tested on standard transverse strength testing machine
- **The setting time and strength tests are recommended for hydraulic limes only.**

References

- **Building Construction :** ***Dr B.C. Punmia***
- **Engineering Material :** ***Rangwala***
- **Internet Web Sites**

Thanks…