

# Lime

- Important materials not only for building purposes, but also for many other manufacturing processes;
- Uses as building material in mortars, aggregate, etc.
- Plastering, whitewashing, base coat for distempering, etc.
- Fluxing material in so many manufacturing processes (e.g., brick, cement, etc.).
- Soil stabilization, aquaculture, water purification, sewerage treatment, etc.

## Properties:

- Good plastic property
- Harden quite easily, especially the hydraulic lime.
- Easily workable
- Withstand moisture
- Good adhering properties with stone and bricks
- Comparatively low shrinkage after slaking, and hence used in lime mortar for masonry work.

## Sources:

- Does not occur in nature in free-state.
- Limestone, shell and kankar are the usual raw materials from which lime is obtained.
- All the raw materials contain  $\text{CaCO}_3$  as chief constituent, when heated  $\text{CO}_2$  is liberated leaving behind  $\text{CaO}$ .
- Raw materials vary in chemical composition & physical properties from place to place.
- Besides this, methods of burning, shaking, storing, etc. also affects the properties of lime.

This is why , lime of uniform quality can not be obtained at all the places.

### **Some important definitions:**

**Calcination:** Process of heating the limestone to redness in the presence of atmospheric air.



#### **Quick lime:**

- Obtained from the calcination of pure lime.
- Having great affinity to moisture.
- Mostly CaO, but a small amount of magnesia MgO may be present.
- Also known as Caustic lime or Lump lime as it comes from kilns.

#### **Slaking:**

- Quick lime has strong affinity to moisture. Adding water in sufficient quantity to quick lime is known as slaking.
- It results in a lot of heat generation, swelling and cracking, and to the end, quick lime gets converted into hydrated lime.

#### **Slaked lime:**

- The product obtained by slaking of calcined lime (quick) is slaked or hydrated lime.
- During slaking, heat generation, swelling and cracking is occurred.
- Rate of slaking depends on: the size of burnt lime lump, atmospheric temperature while slaking, etc.
- Slaking can be done also with steam very speedily under increased pressure in closed drums.
  
- Slaked lime should be used fresh because it has the tendency to absorb carbonic acid from atmosphere in presence of air, which leads to the formation of carbonate of lime particles. Such slaked lime is useless because it loses setting property. This is why, slaked lime should not be kept in damp place.

### Hydraulicity :

- Property of lime which allows it to set (eventually gets hardened) in damp places or under water or in thick masonry wall, where free access of air is not possible.
- This property is due to the crystallizing power of aluminate of silicate of lime.

### Factors responsible for hydraulicity of lime are:

1. Clay: Most important ingredient to impart hydraulicity in lime. A proportion of 8~30% of clay is considered for developing this property. The property decreases if clay% exceeds the specified limit.
2. Soluble silica: Silicates of Ca, Mg & Al are responsible for hydraulicity.
3. Carbonate of magnesia: Reduces slaking and increasing the setting process.
4. Alkalis and metallic oxides: May be present up to 5%; they tend to become soluble silicates at low temperature and help causing hydraulicity.
5. Sulphates : If present in small %, it tends to reduce slaking & increase setting action.

## Classification of lime

Three types: Fat lime, Hydraulic lime and Poor lime.

### 1. Fat lime:

- Is obtained by slaking quick lime; during slaking increases 2~2.5 times in volume and so it is called fat lime.
- Quick lime is obtained from calcination of almost pure limestone (i.e., containing 95% CaO and 5% other materials in the form of impurities).

#### Properties:

- Slow hardening action as being dependent on atmosphere for CO<sub>2</sub>
- Slaking vigorously with hissing sound and a lot of heat is generated.
- Swells 2~2.5 times of quick lime after slaking
- High degree of plasticity
- Soluble in water
- Milky white in color

#### Uses:

1. White washing,
2. Plastering,
3. In mortar with sand, it may be used for thin masonry works. Setting depends on atmospheric CO<sub>2</sub>, so cannot be used at interior situation.

### 2. Hydraulic lime:

- Lime possessing the property of setting under water or in interior works without the presence of atmospheric air is hydraulic lime.
- This property (hydraulicity) is due to the presence of clay (silica, alumina & iron oxide) in lime and depends upon the amount of clay and the type of clay presence in it.

### **Properties of hydraulic lime:**

- Increased % of clay renders lime more hydraulic and makes slaking more difficult;
- With 30% clay content, its chemical composition resembles more or less that of cement;
- Sets under water and also under situations where free air cannot reach; because setting action of hydraulic lime does not depend upon atmospheric air;
- Not perfectly white; appears less sanitary than fat lime;
- Not dissolve in water, but forms a thin plastic paste with water;

### **Composition of hydraulic lime:**

- The limestones are so selected that the %clay in them is limited.
- The temp. in calcination is kept within about  $1250^{\circ}\text{C}$ , which is insufficient to complete the formation of silicates and aluminates of calcium in general. These newly formed compounds are anhydrous and highly cementitious in nature and complex in composition;
- Iron oxide does not take active part in these reactions; Still requires higher temperature to become active.

Thus, the high temp. ( $1250^{\circ}\text{C}$ ) of calcination yield hydraulic limes of the following composition:

- i. Free or quicklime plus magnesia of 40~60%, which is essential to bring about hydration of hydraulic lime.
- ii. Not more than 10% of  $\text{CO}_2$ ; the limit of which indicates the efficiency of calcination process.
- iii. Complex cementitious compounds of Ca, Al and silica in the following percentages (which brings out subsequent hardening of hydraulic lime):

1. Feebly H. lime: 10~15%; slakes slowly & low volume expansion; used for lime mortar in not very important work.
2. Moderately H. lime: 15~25%; slakes very slowly & very low volumetric expansion; used for mortar in good type of masonry works.
3. Eminently H. lime: 25~30%; Slaking and volumetric expansion is hardly noticeable; mostly used for structural works and for works carried out under water.

### 3. Poor lime:

- Contains more than 30% clay.
- Slakes very slowly; Hardens & sets very weakly;
- Does not dissolve in water;
- Forms a thin plastic paste with water;
- Also known as lean lime or impure lime;
- Forms very weak mortar and hence used for interior works only.

### Hydration:

- Reaction of lime (sandstone) with water;
- The hydration brings about lime powder which is used various purposes, such as whitewashing, lime putty, plaster and for general building work.

### Hydration of lime accompanied by:

- Chemical combination with water: The calcined limestone contains the oxide of calcium & Mg in varying proportion which have strong affinity to water:  $\text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2$

- Increase in volume: Hydration is accompanied by an increase in volume, which is to the extent of about 2~2.5 times on hydration for fat lime; but for hydraulic lime, it is about 50%.
- Generation of heat during hydration:

### ***Methods of slaking:***

Two methods:

- i. Hand slaking for small scale
- ii. Mechanical slaking

#### **1. Hand slaking:**

3 types

- i. **By drowning:** Applicable for high calcium lime or fat lime
- ii. **By immersion:** Feebly H. lime
- iii. **By sprinkling:** Hydraulic lime

- Immersion: Lime is filled in a basket and is then immersed in a tub filled with water.
- Sprinkling: H. lime spread on a specially prepared non-porous platform. Water is sprinkled using a watering-can with a hose.

**2. Mechanical slaking:** Hydrated lime essentially consists of a crusher and a hydrator with suitable storage tanks and silos. Devices for conveying the material from one unit to the other are also provided. The hydrated lime is then passed through a suitable sieve to yield a powder of required fineness.

## **Artificial hydraulic lime:**

**Fat lime and clay:** Fat limes or feebly H. limes are calcined and slaked to obtain hydrated powder. Clay in the required proportion is added to this powdered lime to provide with silica, alumina and iron oxide, which are essential to impart hydraulicity.

After lime and clay are thoroughly mixed, water is added to form a stiff paste that is again kneaded well. The stiff mixture is now converted into small hand balls of 3 to 5 cm diameter, and subsequently dried.

The dried balls are calcined in a kiln at the required temperature and then hydrated to form hydraulic lime powder.