Defect of Lime

1- Magnesium carbonates: Lime stones contain magnesium carbonate in varying proportions. Presence of this constituent allows the lime to slake and set slowly, but imparts high strength. Further, the production of heat and expansion are low. The magnesium lime stones are hard, heavy and compact in texture. In burning limestone, the magnesium carbonate is converted to magnesium oxide at a much lower temperature whereas calcium carbonate is oxidised at a little higher temperature. By the time calcium carbonate is oxidised most of the magnesium oxide formed is over burnt. Magnesium lime stones display irregular properties of calcinations, slaking and hardening. Up to 5 per cent of magnesium oxide imparts excellent hydraulic properties to the lime.

2- Clay: It is mainly responsible for the hydraulic properties of lime. It also makes lime insoluble in water. The percentage of clay to produce hydraulicity in lime stones usually varies from 10 to 30. If, it is in excess, it arrests slaking whereas, if in small quantities the slaking is retried. Thus, limes containing 3-5 per cent of clay do not display any hydraulic property and do not set and harden under water. Whereas, when clay is present as 20-30 per cent of lime, the latter exhibits excellent hydraulic properties and is most suitable for aqueous foundations.

3- Silica: In its free form (sand) has a detrimental effect on the properties of lime. Limes containing high percentage of free silica exhibit poor cementing and hydraulic properties. Limes containing 15-20 per cent of free silica are known as poor limes.

4- Iron compound: Iron occurs in small proportions as oxides, carbonates and sulphides. They are converted into Fe_2O_3 at lower

temperatures of calcination. At higher temperatures iron combines with lime and silicates and forms complex silicate compounds. Pyrite or iron sulphide is regarded to be highly undesirable. For hydraulic limes 2-5 per cent of iron oxide is necessary.

5- Carbonaceous matters: Carbonaceous matters in lime are seldom present. Its presence is an indication of the poor quality of lime.

6- Sulphates: Sulphates, if present, slow down the slaking action and increase the setting rate of limes.

7- Alkalis: When pure lime is required the alkalis are undesirable. However, up to 5 per cent of alkalis in hydraulic limes do not have any ill effect but improve hydraulicity.

Definitions

Quick Lime: Pure lime, generally called quick lime, is a white oxide of calcium. Much of commercial quick lime, however, contains more or less magnesium oxide, which gives the product a brownish or grayish tinge. Quick lime is the lime obtained after the calcination of limestone. It is also called caustic lime. It is capable of slaking with water and has no affinity for carbonic acid. The specific gravity of pure lime is about 3.40.

Fat Lime: has high calcium oxide component and, sets and hardens by the absorption of CO_2 from atmosphere. These are manufactured by burning marble, white chalk, calcareous tufa, pure lime stone, sea shell and coral.

Hydraulic lime: contains small quantities of silica, alumina, iron oxide in chemical combination with calcium oxide component. These are

produced from carboniferous lime stones and magnesian limestone. It has the property to set and harden under water.

Hydrated lime: When quick lime is finely crushed, slaked with a minimum amount of water, and screened or ground to form a fine homogeneous powder the product is called hydrated lime.

Lamp Lime: is the quick-lime coming out of the kilns.

Milk lime: is a thin pourable solution of slaked lime in water.

Properties of lime

1. Lime possesses good plasticity and is easy to work with.
2. It stiffens easily and is resistant to moisture.
3. The excellent cementitious properties make it most suitable for masonry work.
4. The shrinkage on drying is small because of its high water retentively.

Uses

In construction slaked lime is mainly used to make mortar for laying masonry and plastering. When so used quick lime should be completely hydrated by slaking from 3 to 14 days, depending upon the kind of lime, temperature, and slaking conditions. Hydrated lime, although immediately usable, is usually improved by soaking overnight or longer. Hydrated lime is often added to Portland cement mortar in proportions varying from 5 to 85 percent of the weight of the cement to increase plasticity and workability. Most of the historical buildings had been plastered in lime. Lime punning about3 mm thick shell lime layer to

improve the plastered surfaces and to give a shining appearance isused very commonly now a days in the new structures. Some of the other uses of lime are manufacture of lime bricks, artificial stones, paints, glass; as stabilizer for soils and as flux in metallurgical processes.

Classification of Limes

According to the percentage of calcium oxide and clayey impurities in it, lime can be classified as lean, hydraulic and pure lime. Since magnesium oxide slakes slowly, an increase in its percentage decreases rate of hydration and so is with clayey impurities as well.

1. Lean or poor lime: It consists of CaO + MgO 80 to 85% with MgO less than 5% and clayey impurities of about more than 7 percent in the form of silica, alumina and iron oxide. It setson absorbing CO_2 from atmosphere.

Characteristic

- Slaking requires more time and so it hydrates slowly. Its expansion is less than that of fat lime.
- It makes thin paste with water.
- Setting and hardening is very slow.
- The color varies from yellow to grey.

Uses: It gives poor and inferior mortar and is recommended for less important structure.

2. hydraulic Lime: It is a product obtained by moderate burning (900°-1100°C) of raw limestone which contains small proportions of clay (silica

and alumina) 5-30 percent and iron oxide in chemical combination with the calcium oxide content (CaO + MgO 70-80% with MgO less than 5%). In slaking considerable care is required to provide just sufficient water and no excess, since an excess would cause the lime to harden. Depending on the percentage of clay present these are classified further as, feebly, moderately and eminently hydraulic lime. It sets under water.

Feebly hydraulic lime**:** has less than 5-10 percent of silica and alumina and slakes slowly, after few minutes (5 to 15). The setting time is twenty one days. It is used in damp places and for less important structures.

Moderately hydraulic lime**:** has 10-20 percent of impurities, slakes sluggishly after 1-2 hours. The setting time is seven days. It is used in damp places.

Eminently hydraulic lime**:** has clayey impurities 20-30 percent and slakes with difficulty. Its initial setting time is 2 hours and final setting time is 48 hours. it is used in damp places and for all structural purposes.

3. Pure, rich or fat: It is soft lime (CaO + MgO more than 85% with MgO less than 4%) obtained by the calcination of nearly pure limestone, marble, white chalk, politic lime stone and calcareous tufa. Also known as white washing lime should not have impurities of clay and stones, more than 5 percent. Fat lime is nearly pure calcium oxide and when it is hydrated with the required amount of water the solid lumps fall to a soft fine powder of $Ca(OH)_2$ and the high heat of hydration produces a cloud of steam. It sets on absorbing CO_2, from atmosphere.

Characteristics

- Slaking is vigorous and the volume becomes 2-3 times.

- It sets slowly in contact with air, and hence is not suitable for thick walls or in wet climate.
- If kept under water a fat lime paste does not lose its high plasticity and consequently does not set and hard.
- 4. sp. gr. of pure lime is about 3.4.

Uses: Fat lime finds extensive use in making mortar, matrix for concrete, base for distemper and in white wash, manufacturing of cement, and metallurgical industry.

Hardening

Depending on the kind of lime and its hardening conditions, distinction is made of three patterns of carbonate, hydrate and hydro-silicate.

Carbonate hardening

Two simultaneous processes take place in lime mortars or concrete from slaked lime.

1. The mixed water evaporates and calcium oxide hydrate crystallizes out of its saturated water solution.
2. Calcium carbonate is formed in accordance with the reaction.

$Ca(OH)_2 + CO_2 + nH_2O = CaCO3 + (n + 1)H_2O$

The crystallization process of calcium oxide hydrate is very slow. Evaporation of water causes fine particles of $Ca(OH)_2$ to stick together and form large $Ca(OH)_2$ crystals which in turn grow together and form a carcass that encloses sand particles. The rate of $CaCO_3$ formation is significant only in the presence of moisture. A film of calcium carbonate

appearing on the surface of the mortar during the initial period of hardening, prevents the penetration of carbon dioxide into the inside layers, and because of this the carbonization process, which is very intensive in the presence of a sufficient amount of carbon dioxide stops almost entirely. The more intensive is the evaporation of water, the quicker is the crystallization of calcium oxide. Therefore, hardening of lime requires an above zero temperature and a low humidity of the surrounding medium. Pure lime paste cracks as a result of considerable shrinkage during drying; this can be prevented by. adding 3.5 pails (by volume) of sand. The introduction of a prescribed amount of aggregate is advisable not only from the economic but also from the engineering stand point, as it improves hardening and reduces drying shrinkage.

Hydrate hardening

It is a gradual conversion of lime mortar and concrete mixes from ground unslaked lime into a rock-like hard body, resulting from the interaction of lime with water and the formation of calcium oxide hydrate. First, lime dissolves in water to give a saturated solution, which over saturates rapidly because water is absorbed by the remaining unslaked grains. Rapid and strong over-saturation of a mortar, prepared from unslaked lime, results in formation of colloidal masses, which appear because calcium oxide hydrate formed by mixing lime with water consists of particles very close in size to those of the colloids. Colloidal calcium hydrate coagulates quickly into a hydrogel which glues the grains together. As water is partly sucked in by the deeper layers of grains and partly evaporates, the hydrogel thickens and thus increases the strength of the hardening lime. The hydrogel formed in the process of hardening of slaked lime holds much water and its adhesiveness is poor, which is not

so for hardening unslaked lime. As slaking lime hardens, crystallization of calcium oxide hydrate increases its strength. subsequent carbonization of calcium oxide hydrate improves the strength of the hardened mortar.

Hydro-silicate hardening

When lime-sand mixtures are treated by high-pressure steam (8-16 atm) corresponding to temperatures between 175 and 200°C, lime and silica interact in the autoclave and form calcium hydro silicate which ensures high strength and durability of manufactured items. in the autoclave method of hardening lime-sand materials, lime does not play the part of a binding material, whose hydration and carbonization gives rise to a stony body of required strength at usual temperatures. In the given instance, lime is one of the two components that interact and form calcium hydro silicate which is the chief cementing substance. The required strength results not from the physical cohesion of the binder hydrate formations with the grains of the aggregate, but from chemical interaction between the chief components of the raw materials, lime and quartz sand.