

Material with adhesive and cohesive properties which make it capable to bond mineral fragments into a compact whole. This definition embraces a large variety of cementing materials, among them:

1. Gypsum plaster
2. Lime
3. Cement

1. Gypsum plaster:

Gypsum plaster comprise all that class of plastering and cementing materials which are obtained by partial or complete dehydration of natural gypsum and to which contain materials that serve as retarders or hardeners, or that impart greater plasticity to the product, may not have been added during or after calcinations.

1.1 Raw materials – Gypsum rocks:

Pure gypsum is a hydrous lime sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), the composition of which by weight is:

Lime sulfate	↙	Lime CaO	– 32.6%
	↘	Sulfur trioxide SO_3	– 46.5%
Water H_2O			– 20.9
Total =			– 100 %

Natural deposit of gypsum are very seldom pure, the lime sulphated being adulterated with silica, alumina, iron oxide, calcium carbonate and magnesium carbonate. The total of all impurities varies from a very small amount up to a maximum of about 6%.

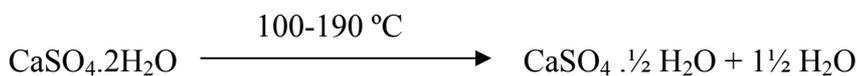
1.2 Manufacture of gypsum plaster:

1.2.1 Process of manufacture:

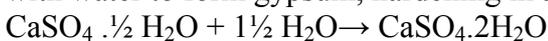
There operations are involved in the process of manufacturing plaster. Crushing, grinding and calcinations. Rock gypsum is crushed to fragments about 25mm in diameter, which are passed through a finishing mill. The grain gypsum is then calcined in rotary kilns.

1.2.2 Theory of calcinations:

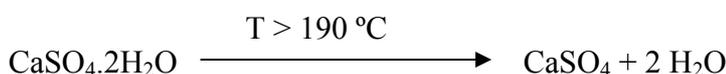
If pure gypsum is subjected to any temperature above 100 °C, but not exceeding 190 °C, three-fourth of the water of combination originally present is driven off:



The resultant product is called plaster of Paris ($\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$). Plaster of Paris readily recombines with water to form gypsum, hardening in a very few minutes:



If the gypsum is calcined at temperature much above 190 °C it losses all its water of combination, becoming an anhydrous sulfate of lime:



1.3 Gypsum products:

1.3.1 Plaster of Paris:

Produced by calcinations of a pure gypsum, no foreign materials being added either during or after calcinations.

1.3.1.1 Uses:

- a. It is used as a wall plaster in finish coat.
- b. It is used as a mortar for masonry construction.
- c. It is used for casting ornamental work.

1.3.1.2 Chemical requirements in accordance with Iraqi standard No. 28/1988:

- a. The sum of soluble salts expressed as ($\text{Na}_2\text{O}+\text{MgO}$) not more than 0.25% by weight of plaster.
- b. The percentage of chemically combined water should be between 4-9%.
- c. The percentage of impurities not more than 5%.
- d. The percentage of SO_3 not less than 45%
- e. The percentage of CaO not less than 30%.

1.3.1.3 Physical requirements in accordance with Iraqi standard No. 28/1988:

- a. Fineness: The percentage retained on 1.18mm sieve not more than 0%.
- b. Setting time should be between 8-25 minute.
- c. Mechanical resistance: The diameter impression resulted by a dropping ball not more than 5mm.
- d. Compressive strength: Not less than 5MPa for standard cube 50*50*50mm.
- e. Modulus of rupture: Not less than 1.5MPa

1.3.2 Ordinary plaster:

It is a hemi hydrate product ($\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$), produced by the calcinations of a gypsum containing certain natural impurities or by the addition to a calcined pure gypsum of certain materials which serve to retard the set or render the product more plastic.

1.3.2.1 Uses:

- a. It is used as a wall plaster in first coat.
- b. It is used as a mortar for masonry construction.

1.3.2.2 Chemical requirements in accordance with Iraqi standard No. 28/1988:

- a. The percentage of SO_3 not less than 35%.
- b. The percentage of CaO not less than 25%.
- c. The sum of soluble salts expressed as ($\text{Na}_2\text{O}+\text{MgO}$) not more than 0.25% by weight of plaster.
- d. The percentage of chemically combined water not more than 9%.
- e. The percentage of loss of ignition not more than 9%

1.3.2.3 Physical requirements in accordance with Iraqi standard No. 28/1988:

- a. Fineness: The percentage retained on 1.18mm sieve not more than 8%.
- b. Setting time should be between 8-25 minute.
- c. Compressive strength: Not less than 3MPa for standard cube 50*50*50mm.

1.3.3 Technical plaster:

It is produced by mixing two types of plaster: Hemi hydrate product ($\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$) and anhydrous product (CaSO_4) with 50% for each.

1.3.3.1 Uses:

- a. It is used as a wall plaster in first coat.
- b. It is used as a mortar for masonry construction.

1.3.3.2 Chemical requirements in accordance with Iraqi standard No. 28/1988:

- a. The percentage of SO_3 not less than 50%.
- b. The percentage of CaO not less than 27%.
- c. The sum of soluble salts expressed as ($\text{Na}_2\text{O}+\text{MgO}$) not more than 0.25% by weight of plaster.
- d. The percentage of chemically combined water not more than 9%.
- e. The percentage of loss of ignition not more than 9%

1.3.3.3 Physical requirements in accordance with Iraqi standard No. 28/1988:

- a. Fineness: The percentage retained on 1.18mm sieve not more than 5%.
- b. Setting time should be between 12-20 minute.
- c. Compressive strength: Not less than 6MPa for standard cube 50*50*50mm.
- d. Modulus of rupture: Not less than 2MPa
- e. Mechanical resistance: The diameter impression resulted by a dropping ball not more than 5mm.

1.3.4 Anhydrous plaster:

It is produced by the complete dehydration of gypsum, the calcinations being carried on at temperature exceeding 180 °C. It has low solubility in water compared with ordinary plaster, thus certain material can be added during the grinding process to increase its ability to react with water.

1.3.4.1 Uses:

- a. As wall plaster in all coats.
- b. It is used as a mortar for masonry construction.

1.3.5 Keen cement:

It is anhydrous plaster produced the calcinations, at a red heat or over, of gypsum to which certain substances, usually ($\text{Al}_2(\text{SO}_4)_2 \cdot 18\text{H}_2\text{O}$) had been added.

1.3.5.1 Properties:

- a. Its set is extremely slow, usually between 1-7 hours.
- b. It gains in strength very gradually, but ultimately attains a great degree of hardness and a strength exceeding that of any ordinary gypsum plaster.
- c. Its plasticity is high.
- d. Its resistance to water is higher than ordinary plaster.

1.3.5.2 Uses:

- a. It is used as a wall plaster in finishing coat and corners.
- b. It is used as a wall plaster in areas exposed to moisture instead of cement and lime.

1.4 Properties of gypsum plasters:

1.4.1 Setting and hardening:

The term “ setting “ is meant the initial loss of plasticity, whereas “ hardening “ means the subsequent gain in strength and in ability to resist indentation or abrasion. The setting of plaster of Paris and other gypsum plasters is a process recombination of the partly or totally dehydrated lime sulfate or gypsum.

1.4.2 Percentage of water in plaster:

The water-plaster ratio is greatly affecting the strength of plaster. The higher the water plaster ratio, the greater are the plasticity and flow ability of plaster, but when it exceed the optimum value, part of water remain between paste particles and tends to pull the particles apart, reducing the cohesion between them and between the plaster and building units and leading to a reduced strength and durability.

1.4.3 Condition of setting:

The strength of plaster drops to a large degree when the plaster remains wet for a long period exceeding 3-days after setting. The reason is due to decomposition of some of plaster crystals in water, leading to reduced chemical adhesion.

2. Lime:

2.1 Definition and classification:

2.1.1 Quick lime:

Is the name applied to the commercial form of calcium oxide CaO , obtained by the calcinations of a stone in which the predominating constituent is calcium carbonate CaCO_3 , often replaced, to a greater or less degree by magnesium carbonate MgCO_3 , this product being one that will slake on the addition of water.

2.1.2 Hydrated lime:

Is quick lime has been chemically satisfied with water during manufacture.

2.2 Raw materials – Lime stone rocks:

Pure lime stone rocks consist entirely of CaCO_3 . Pure calcium carbonate consists of 56 parts by weight of CaO to 44 parts of CO_2 .

Lime stones encountered in practice depart more or less from this theoretical composition. Part of the lime is almost always replaced by a certain percentage of magnesia MgO . In addition to magnesia, silica, iron, oxide and alumina are usually present and too slight extent, sulfur, and alkalis.

The physical character of the lime stone has an effect upon the burning temperature. A naturally, coarse, porous stone is acted upon by heat much more rapidly than a dense, finely crystalline stone, and may be burned more rapidly and at a lower temperature.

2.3 Manufacture of lime – Theory of calcinations:

The burning or calcinations of lime accomplishes three objects:

- a. The water in the stone is evaporated.
- b. The lime stone is heated to the request temperature for chemical dissociation.
- c. The CO_2 is driven off as a gas, leaving the oxides of calcium and magnesium.

2.4 Uses of quick lime:

Lime may be used as:

- a. Building materials.
- b. Finishing materials.

2.5 Properties of quick lime:

2.5.1 Plasticity:

The term “plasticity” is commonly used to describe the spreading quality of the material of the material in plastering. If it spreads easily and smoothly, it is plastic, if it sticks under the trowel, or cracks, and drops behind the trowel, it is non plastic.

2.5.2 Sand- carrying capacity:

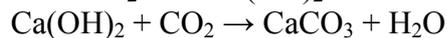
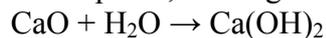
Practically all lime used structurally is made up in the form of mortar by the addition of sand to lime paste for the following reasons:

- a. Sand is cheaper than lime.
- b. To diminish the great shrinkage which accompanies the setting and hardening of lime, and to prevent the consequent cracking.
- c. To counteract the extreme stickiness of some high- calcium limes.

It is important that the “sand- carrying capacity” of the lime be properly established. If too little sand is used, excessive shrinkage will cause a weakening of bond between the plaster or mortar and the masonry materials or plastered surface. On the other hand, too much sand produces a non plastic and weak mortar.

2.5.3 Setting time:

The setting of lime and lime mortar is a chemical process involving the evaporation of the large excess of water used in forming the lime paste, followed by the gradual replacement of the water of hydroxide by CO₂ in the atmosphere, causing the lime hydrate to revert to the original calcium carbonate.



2.5.4 Tensile and compressive strength of lime mortars:

The physical properties of lime mortar vary with the:

- a. Chemical composition of the lime: Magnesia lime makes it stronger than calcium limes.
- b. Character of the sand: Fine sand makes stronger mortar than coarse sand.
- c. The amount of water: Suitable amount of water produces stronger lime mortar.
- d. The conditions under which the mortar sets: The humidity and amount of CO₂ in the atmosphere influence the rate of setting of lime drying the air and charging it with carbon dioxide, greatly accelerating the setting process.

2.6 Hydrated lime:

2.6.1 Process of manufacture:

Hydrated lime is a dry powder resulting from the hydration, at the place of manufacture, of ordinary quick lime. Three stages of manufacture characterize the preparation of hydrated lime:

- a. The quick lime is crushed or pulverized to a fairly small size.
- b. The crushed materials are thoroughly mixed with a sufficient quantity of water.
- c. The slaked lime is, by air separation, screening, or other wise separated from lumps of anhydrate lime and impurities, or the entire mass must be finely pulverized.

2.6.2 Uses:

Hydrated lime may be used as:

- a. Building materials.
- b. Finishing materials.

2.6.3 Properties:

- a. Mortar prepared from hydrated lime is generally inferior to those prepared from quick lime from the stand point of plasticity and sand – carrying capacity.
- b. The strength of hydrated lime mortars, both in tension and in compression, is some what higher than that of the corresponding quick lime mortars.
- c. Hydrated lime mortars are more quickly setting than from ordinary quick lime mortars.