Bonding Materials

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

1- Gypsum Plaster.
2- Lime.
3- Cements.

Gypsum Plaster

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

Manufacture of Gypsum Plaster

Raw Materials- Gypsum Rocks

Pure gypsum is a hydrous lime sulphate ($CaSO_4+2H_2O$). The composition of which by weight it:

Lime Sulphate ($CaSO_4$)

+Water (H_2O) (20.7%)

- Lime (CaO) (32.6%)
- Sulfur (SO_3) (46.5%)

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

Process of Manufacture

Three operations are involved in the process of manufacturing plaster: crushing, grinding and calcination. Rock gypsum is crushed to fragments about (25mm) in diameter, which are passed through an intermediate crusher and then pulverized in a finishing mill. The ground gypsum is then calcined rotary kilns.

Theory of Calcination

If pure gypsum is subjected to any temperature above 100°C, but not exceeding 190°C, three – fourths of the water of combination originally present is driven off. The resultant product is called plaster of Paris ($CaSO_4.1/2\ H_2O$). Plaster of Paris recombines with water to form gypsum, hardening in a very few minute.

If the gypsum is calcined at temperatures much above 190°C it losses all its water of combination, becoming an anhydrase sulfate of lime ($CaSO_4$).

Gypsum Products

1- Plaster of Paris: produced by calcination of pure gypsum, no foreign materials being added either during or after calcination.

Uses:-

1- It is used as a wall plaster in finishing coat.

2- It is used as a mortar for masonry construction.

3- It is used for casting ornamental work.

Chemical Requirements in accordance with Iraqi standard No.28-1985

1- The sum of soluble salts expressed as ($Na_2O + MgO$) $\geq$ 0.25% by weight of plaster.

2- The percentage of chemically combined water should be between (4-9%).
3- The percentage of impurities ≥ 5%.

Physical Requirements in accordance with Iraqi standard No.28-1985

1- Fineness: the percentage retained on 1.18mm sieve ≥ 1%.
2- Setting Time: should not be less than 20 minutes.
3- Mechanical Resistance: the diameter of impression resulted by a dropping ball ≥ 5mm.
4- Compressive Strength: ≤ 5N/mm^2.

2-Ordinary Plaster: It is hemihydrate product ($CaSO_4.1/2H_2O$), produced by the calcination 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.

Uses:-

1- It is used as a wall plaster in the first and second coat.
2- It is used as a mortar for masonry construction.

Chemical Requirements

1- The percentage of SO3 ≤ 35%.
2- CaO ≤ 2/3 SO3.
3- The sum of soluble salts expressed as (Na_2O+MgO) ≥ 0.25% by weight of plaster.
4- The percentage of chemically combined water should be between (4-9%).

Physical Requirement

1- Finesses: the percentage retain on 1.18mm sieve ≥ 5%.
2- Setting Time: should be between (5-15 min).
3- Compressive Strength: ≤ 3N/mm^2.
4- Modulus of Rapture: ≤ 1.2 mm^2.

3-Technical Plaster: technical plaster is produced by mixing two types of plaster hemihydrate products. ($CaSO_4$ .1/2H_2O) and anhydrase products $CaSO_4$ (50%) for each.

Uses:

1- It is used as a wall plaster in the first and second coat.
2- It is used as a mortar for masonry construction.

Chemical Requirements:

1- The percentage of SO_3 ≤ 50%.
2- CaO ≤ 2/3 SO_3.
3- The sum of the soluble salts expressed as (Na_2O+MgO) ≥ 0.25% by weight of plaster.
4- The percentage of chemically combined water ≥ 3%.

Physical Requirements:

1- Fineness: the percentage retained on 1.25 sieve ≥ 5%.
2- Setting time: should be between 5 minutes – 15 minutes.
3- Compressive strength ≤ 10 N/ mm^2.
4- Flexural strength ≤ 3 N/ mm^2.

4-Anhydrose Plaster: anhydrous plaster is produced by the complete dehydration of gypsum, the calcination being carried on at temperature exceeding 190°C. It has low solubility in water compared with ordinary

plaster, thus certain materials can be added during the grinding process to increase its ability to react with water.

Uses:

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

5-keen Cement: is anhydrous plaster produced by the calcination, at reed heat or over, of gypsum to which certain substances, usually alum $Al_2(SO_4)_3$ have been added.

Properties:

1- It set is extremely slow, usually between 1-4 hours.
2- It gains in strength very gradually, but ultimately attain a great degree of hardness and a strength exceeding the of any ordinary gypsum plaster.
3- Its plasticity is high.
4- Its resistance to water is higher than ordinary plaster.

Uses:

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

properties of gypsum plaster:

1- Setting and Harding: 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 plaster is a process of

recombination of the partly or totally dehydrated lime sulfate of gypsum.

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 plaster particles and tend to pull the particles a part, reducing the cohesion between them and between the plaster and building units and leading to a reduce strength and durability.

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 sum of plaster crystals in water leading to a reduced chemical adhesion.

Lime

1-Quick Lime***:*** Is the name applied to the commercial form of calcium oxide (CaO), obtained by the calcination 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.

Uses:-

1- Building materials.
2- Finishing materials.

Properties:-

1- Plasticity: The term plasticity is commonly used to describe the spreading quality 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- Sand – Carrying Capacity: Partially 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 this accompanies the setting and hardening of lime, and to prevent the consequent cracking.

c- To counteract the extreme stickiness of some high-calcium lime

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 the hydroxide by (CO_2) in the atmosphere, causing the lime hydrate to revert to the original calcium carbonate.

$Cao + H_2O \longrightarrow Ca(OH)_2$

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

4- Physical Properties:- The physical properties of lime mortar vary with the:-

a- Chemical composition of the lime: Magnesia limes make stronger mortar 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 the amount of (CO_2) 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-Hydrated Lime: Is quick lime that has been chemically satisfied with water during manufacture.

Uses:-

1- Building materials.
2- Finishing materials.

Properties:-

1- Mortars prepared from hydrated lime are generally inferior to those prepared from quick limes from the standpoint of plasticity and sand-carrying capacity.
2- The strength of hydrated lime mortars, both in tension and in compression, is somewhat higher than of the correspond quick lime mortars.
3- Hydrated lime mortars are more quickly setting than from ordinary quick lime mortars.