Bonding Materials

Bonding Materials(المواد الرابطة):-

Materials with adhesive and cohesive properties (مواد ذات خواص تماسكية وتلاصقية) Which make it capable of bonding mineral fragments into a compact whole(قادرة على ربط الاجزاء المعدنية بشكل متراص). This definition embraces a large variety of cementing materials among them (هذا التعريف يشمل انواع مختلفة من المواد الاسمنتية من بينها) :-

- **Gypsum Plaster (الجص).**
- **Lime (النورة).**
- **Cements (الاسمنت).**

Gypsum Plaster (الجص):-

Gypsum plasters comprise (تضم) all that class of plastering and cementing materials which are obtained by the partial complete dehydration of natural gypsum (تجفيف الجبس الطبيعي) and to which contain materials that serve as retarders or hardeners (تحوي مواد تعمل بمثابة مبطئات للتصلب), or that of greater plasticity to the product , may or may not have been added during or after calcination.

Manufacture of Gypsum Plaster (صناعة الجص):-

Raw Materials - Gypsum Rocks:-

Pure gypsum is a hydrous lime (الجير المائي) sulfate ($CaSO_4 + 2H_2O$) the composition of which by weight is :-

Lime Sulfate ($CaSO_4$)	Lime (CaO)	32.6 %
	Sulfate trioxide (SO_3)	46.5 %
Water (H_2O)		20.9 %
		Σ = 100 %

Natural deposite (الرواسب الطبيعية) of gypsum are very seldom pure (نادرا ما تكون نقية) , the lime sulfate being adulterated (ملوثة) 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%).

Process of Manufacture (عمليات صناعة الجص):-

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

Theory of calcination (نظرية الحرق):-

If pure gypsum is subjected to any temperature above (100 °C) , but not exceeding (190 °C) , three-fourth of the water of combination(المزيج) originally present is driven off (يتحرر) . The resultant product is called (Plaster of paris) (جص باريس) ($CaSO_4 . 1/2H_2O$). Plaster of Paris readily recombines (يمزج بسهولة) with water to form gypsum , hardening in a very few minutes.

If the gypsum is calcined at temperatures much above (190 °C) it loses all it's water of combination, becoming an anhydrous sulfate of lime ($CaSO_4$).

Gypsum Products (منتجات الجص):-

1- Plaster of Paris (جبس باريس) :- 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 (صب الاعمال الزخرفية).

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

1. The sum of soluble salts expressed as ($Na_2O + MgO$) $\not>$ 0.25% by weight of plaster
2. The percentage of chemically combined water should be between 4 - 9 %
3. The percentage of impurities $\not>$ 5%

Physical Requirements - Iraqi standard No. 28 - 198.

1. Fineness : the percentage retained on 1.18 mm sieve $\not>$ 1%
2. Setting time : should not be less than 20 minutes
3. Mechanical resistance : the diameter of impression resulted by a dropping ball $\not>$ 5 mm
4. Compressive strength : $\not<$ 5 N/mm^2.

2- **Ordinary Plaster (الجص الاعتيادي) :- it is a hemihydrate (نصف مماه) product - *($CaSO_4$. 1/2H_2O)*, produced by the calcination of a gypsum containing certain natural impurities , or by addition to a calcined pure gypsum of certain materials which serve to retard the set or render(يجعل) 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 SO_3 ≤ 35%

2- CaO ≤ $\frac{2}{3}$ SO_3

3- The sum of the soluble salts expressed as (Na_2O + MgO) ≯ 0.2% by weight of plaster.

4- The percentage of chemically combined water should be between 4-9 %

Physical Requirements

1- Fineness : The percentage retained on 1.18 mm sieve ≯ 5%

2- Setting time : should be between 5 minutes - 15 minutes.

3- Compressive strength ≮ 3 N/mm^2

4- Modulus of rupture ≮ 1.2 N/mm^2

3- Technical Plaster (الجص الفني) :- it is produced by mixing two types of plaster a hemihydrate product *($CaSO_4 . 1/2H_2O$)*, and anhydrous (اللامائي) product *$CaSO_4$* with (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 ≮ $\frac{2}{3}$ 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 mm 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- Anhydrous Plaster (الجص اللامائي) :- Anhydrous Plaster is produced by the complete dehydration (التجفيف الكامل) of gypsum , the calcination being carried on at temperatures exceeding (190 °C). it has low solubility (قابلية ذوبان منخفضة) in water compared with (مقارنة مع) ordinary plaster, thus certain materials can added during the grinding process to increase it's ability to react with water. It is used :-

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

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

5- Keen cement (سمنت كين) :- Is anhydrous Plaster produced by the calcination at red heat (الحرارة الحمراء) or over , of gypsum to which certain substances , usually alum $Al_2(SO_4)_3.18\ H_2O$ have been added.

Properties :-

1- It's set is extremely slow (بطيء بشدة) , usually between (1-4) hours.

2- It gains in strength very gradually , but ultimately attain a great degree of hardness and a strength exceeding of any ordinary gypsum plaster.

3- It's plasticity is high (ذو لدونة عالية).

4- It's resistance to water is higher than ordinary plaster.

It is used :-

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

Properties of gypsum plasters:-

1- **Setting and hardening**

The term "Setting" (التجمد) is meant the initial loss of plasticity(تعني فقدان اللدونة) , Whereas "Hardening" (التصلب) means the subsequent gain (التحصيل اللاحق) in strength and in ability to resist indentation or abrasion (الاحتكاك والفجوات) . The setting of plaster of Paris and other gypsum plasters is a process of recombination (اعادة مزج) of the partly or totally dehydrated lime sulfate or gypsum.

2- **Percentage of water in plaster**

The water – plaster ratio is greatly affect (تؤثر على) the strength pf plaster. The higher the water plaster ratio , the greater are the plasticity and flowability(السيولة) of plaster , but when exceed the optimum value , part of water remain between plaster particles and lends to pull (تساعد على دفع) the particles apart , reducing the cohesion between them and between the plaster and building units and leading to a reduced strength and durability(تقلل قوى التماسك بين الجص والوحدات البنائية وبالتالي تقلل من المقاومة والديمومة).

3- **Condition of Setting**

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

Lime (النورة):-

Definition and classification:-

1- **Quicklime (الجير الحي) :-**

Is the name applied to the commercial form of calcium oxide (CaO) , obtained by the calcination of a stone in which the predominating (غالب) constituent (مكوناته) is calcium carbonate ($CaCO_3$) often replaced (غالبا ما تبدل) , to a greater or less degree by magnesium carbonate ($MgCO_3$) , this product being on that with slake (اضعف) on the addition of water.

2- **Hydrated lime :-** **Is quicklime that has been chemically satisfied (متوافق) with water during manufacture.**

Manufacture of Lime :-

- ## Limestone Rocks :-

Pure limestone rocks consist entirely (كليا) of ($CaCO_3$) . Pure calcium carbonate consist of (56) parts by weight of (CaO) to (44) part of (CO_2).

Limestones encountered (واجه) 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 , to a slight extent (الى حد طفيف) , sulfur and alkalis.

The physical character (الدور الفيزيائي) of the limestone has an effect upon the burning temperature. A naturally coarse , porous stone (الحجر المسامي) is acted upon by heat much more rapidly than a dense , finely crystalline stone (الاحجار البلورية) , and may be burned more rapidly and at a lower temperature.

Theory of Calcination :-

The burning or calcination of lime accomplishes (تنجز ب) three objects :-

- **The water in the stone is evaporated.**
- **The limestone is heated to the requisite (ضروري) temperature for chemical dissociation (تفكك) .**
- **The (CO_2) is driven off (يتحرر) as a gas , leaving (تاركا) the oxides of calcium and magnesium.**

Uses of Quicklime :- lime may be used as :-

- **Building material.**
- **Finishing material.**

Properties of Quicklime :-

1- Plasticity :- The term plasticity is commonly used to describe the spreading(الانتشار) quality of the material in plastering. If it spreads easily and smoothly (بسلاسة) , it is plastic , if it sticks under the trowel , or cracks , and drops behind the trowel , it is non-plastic.

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 (يقلل) the great shrinkage (الانكماش) which accompanies (يرافق) the setting and hardening of lime and to prevent the consequent cracking(التشققات اللاحقة) .

C- To counteract (مواجهة) the extreme stickness 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 masonary materials or plastered surface. On the other hand , too much sand produced a non-plastic and weak mortar.

3- <u>Setting time :-</u> The setting time of lime and lime mortar is a chemical process involving (تشمل) 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(للعودة) to the original calcium carbonate.

4- <u>Tensile and compressive strength of Lime mortars</u>

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 produced stronger lime mortar.

D- The condition under which 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.

Hydrated Lime (النورة المطفأة):-

Process of Manufacture :-

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

1- The quicklime is crushed or pulverized to a fairly (تماما) small size.
2- The crushed material is thoroughly (بعناية) mixed with a sufficient quantity of water.
3- The slaked lime is , by air separation(فصل) , screening(غربلة) , or otherwise separated from lumps(كتل) of unhydrated lime and impurities (الشوائب) , or the entire mass must be finely pulverized.

Uses :- Hydrated lime may be used as :-

1- Building material (مادة بنائية).
2- Finishing material (مادة انهاء).

Properties :-

1- Mortars prepared from hydrated lime are usually inferior (ادنى) to those prepared from quicklime from the standpoint (وجهة نظر) of plasticity and sand – carrying capacity.
2- The strength of hydrated lime mortars , both in tension and in compression , is somewhat (قليلا) higher than that of the corresponding (المقابلة / المناظرة لها) quicklime mortar.
3- Hydrated lime mortars are more quickly setting (تتجمد بسرعة) than from ordinary quicklime mortars.