Gypsum

Gypsum is a non-hydraulic binder occurring naturally as a soft crystalline rock or sand. Pure gypsum is a white translucent crystalline mineral and is so soft that it can be scratched by a finger nail. When heated to 200°C, pure gypsum loses its luster and its specific gravity is increased from 2.3 to 2.95 due to the loss or water of crystallization Gypsum has a unique property of molding. When heated it gives up combined water and easily turns into powder.On adding water to the powder it can easily be shaped and molded, and in a short time it hardens again and becomes similar to what it was in its natural state. When water is added the gypsum forms interlocking crystals. As the gypsum hardens it is this crystallization that makes it such an effective fire resisting material. There are two commercial varieties of crude gypsum, rock gypsum and gypsum or gypsiteused the manufacture of gypsum binding material. These substances consist principally of a hydrous sulphate of lime ($CaSO_4$ + $2H_2O$) with varying percentages of silica, carbonate oflime, carbonate of magnesia, and iron oxide. Building gypsum is an air-setting binder composedmainly of hemihydrate gypsum and obtainedprocessing gypsum at temperatures 150°C-160°C.Gypsum items have a number of valuable properties like relatively small bulk density,incombustibility, good sound absorbing capacity,good fire resistance, rapid drying andhardening with negligible shrinkage, superior surface finish, resistance to insects and rodents and low energy input during burning to produce gypsum plaster. The major short comings areits poor strength in wet state and high creep under load. Gypsum plaster, e.g., Plaster of Paris, wall plaster stucco, and hard finish plaster are extensively used in wall construction.

Effect of Heat and moisture

The water of crystallized in the gypsum ($CaSO_4.2H_2O$) is not held firmly by the mineral.Therefore, when it is heated to about 160°C it loses a part of water of crystallization and isknown as half-hydrate gypsum.

$$2CaSO_4.2H_2O \xrightarrow{160^o C} 2CaSO_4.\ 1/2\ H_2O + 3H_2O$$

At still higher temperatures (About 200°C), gypsum loses all its water of crystallization andturns out into anhydrate gypsum.

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The lost water of crystallization can be regained under favorable damp or moist conditions.

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Setting and Hardening

The setting and strengthening of gypsum are due to intergrowth of very fine and poorly soluble crystals of dehydrated gypsum as they precipitate from a solution which remainoversaturatedas long as the hydration of gypsum proceeds.

Following are the two theories ofsetting of gypsum.According to the crystallization theory proposed by Le-chatelier when water is added to gypsum, the latter dissolves forming asaturated solution of dehydrate gypsum. Since thesolubility of hemihydrate gypsum is about 3.5times more than of dehydrated gypsum, thesolution that is saturated with respect to the hemihydrate gypsum causes dehydrated gypsumto crystallize. In this process the concentration of hemihydrate gypsum is reduced causingmore of it to dissolve until again the solution isoversaturated and consequently again yielding crystals of dehydrate gypsum. The process continues until all the hemihydrate gypsum ishydrated and crystallized.

According to colloidal theory when water is added to gypsum, the hemihydrate gypsum goes into solution until the latter is saturated. in an oversaturated solution, the interaction ofwaterwith the solid hemihydrate continues on their surface due to high mutual chemicalaffinity. The resultant dehydrated gypsum fails to dissolve further and precipitates as an unstable disperse colloid mass in the form of gel, the process being accompanied by the settingof the mass. The resultant crystals grow both in number and size, while orienting randomlyand intertwining, convert the jelly like mass into a crystalline growth. The resultant $CaSO_4.2H_2O$crystals grow into a single crystalline concretion which on drying becomes very strong.Gypsum sets within 20 minutes and it is difficult to useit for some purpose. Suitable settingretarders like lime-kerat in glue and sulphite -alcohol vine may be used.

Manufacture

Low heat burning Variety

A 75 per cent dehydrated gypsum is referred to as plasters of Paris. The pulverized of plasters of Paris is the basic material used to make many of the gypsum building materials. For refined grade of Plaster of Paris the oven, kettle and rotary processes are used. Hard finish plaster ismade in kilns similar to that used in calcining lime.

The excavated raw materials are crushed, and if the kettle process is used, ground untilabout 60 per cent pass No. 100 sieve. In the rotary process the final pulverization is omitted until calcination is completed.The kettles employed for calcinations are 2.5 or .3 m in diameter and about 2 m high. The pulverized material is chuted into the kettle and temperature raised gradually so as to drive off the mechanically held water. At about 100°C the whole mass bubbles up violently and then sinks. At 150°C the combined water begins to boil out and between 170° and 200°C the process is stopped. The kettle process requires about 2 to 3 hours to calcine a charge yielding 5 to 6tons. The calcined product is then cooled partially in a vat and is sent to the screens. Residuesfrom the screen are ground; the fines are stored in bins.

In the rotary process the raw material is crushed to pass through 25 mm mesh and is then fedinto a rotating cylinder inclined to the horizontal. Calcination is accomplished with the introduction of hot furnace gases. The roasted material is conveyed to calcining vats in which further changes are bought by the heat within the material. The product is then ground screened and stored.in case of Plaster of Paris or stucco the time of setting is delayed by adding fraction of one per cent of retardant like glue, saw dust or blood after the plaster has cooled to increase thehandling time. Cattle hair or wood fiber is introduced for cohesiveness of plastics. Wall plasters made from pure raw materials are adulterated with 15-20% of hydrated lime, the addition isnot required for the raw materials containing considerable amount of clay. If instead of using moderate heating the gypsum is heated sufficiently to drive off all the water, theproduct nolonger combines readily with water to form a useful plastering material, if small quantity ofaccelerating salts is added to it, a useful range of materials is again formed. These are known asanhydrous gypsum plasters or hard burnt plasters.

High Burning variety

Anhydrite cement is obtained by burning natural dehydrate gypsum at a temperature of about 700°C and then grinding the product together with hardening catalyzers (lime, mixture of sodium sulphate with green or blue vitriol, bunted dolomite, granulated basic blast-furnace slag, etc). A typical anhydrite binder may be of the following composition: lime, 2-5%; a mixture of sodium bisulphate or sulphate with green or blue vitriol in amounts of 0.5 to 1% each; dolomiteburned at 800-900°C, 3-8%; granulated basic blast-furnace slag, 10-15%. Green and bluevitriol consolidate the surface of hardened anhydrite cement, so that the catalyzers do not seep out and discolor the item's surface. The action of the catalyzers is due to the abilityof anhydrite,to form complex compounds with various salts in the form of an unstable multiple hydrate, which then decomposes yielding $CaSO_4.2H_2O$. Anhydrite cement can also beobtainedbygrinding natural anhydrite with the above additives. Anhydrite cement is a slowly setting binder; its setting starts not earlier than in 30 min and ends not later than in 24 hours. It is used for preparing brick-laying and plastering mortars,concretes, heat insulating materials, artificial marble and other ornamental items.A variety of anhydrite cements is the high-burned gypsum (estrich gypsum). It ismanufactured by burning natural gypsum or anhydrite at a temperature between 800 to 1000°C followed by fine grinding. This results not only in complete dehydration but also in partial decomposition of anhydrite with the formation of CaO(3-5%) according to the reaction$CaSO_4 = CaO + SO_3$. When ostrich-gypsum is mixed with water, CaO acts as a catalyzer whichpromotes the hardening of the anhydrite cement in a manner discussed above. High-burned gypsum is used to prepare brick-laying and plastering mortars, to build mosaicf1oors, to manufacture artificial marble, etc. Items from high-burned gypsum have low heatand soundconductivity, higher frost and water resistance and a smaller tendency toplasticdeformation than products from building gypsum.