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.

There are two commercial varieties of crude gypsum:-

1- Rock gypsum

2- Gypsum or gypsite

These substances consist principally of a hydrous sulphate of lime ($CaSO_4 + 2H_2O$) with varying percentages of silica, carbonate of lime, carbonate of magnesia, and iron oxide.

Effect of Heat and Moisture on Gypsum

The water of crystallization 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 is known as half-hydrate gypsum.

$$\underset{\text{Gypsum}}{2CaSO_4 \cdot 2H_2O} \xrightarrow{160°C} \underset{\text{Plaster of paris}}{2CaSo_4 \cdot \frac{1}{2} H_2O} + 3H_2O$$

At still higher temperatures (About 200°C), gypsum loses all its water of crystallization and turns out into a hydrate gypsum.

$$CaSO_4 \cdot 2H_2O \xrightarrow{200°C} CaSO_4$$

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

$$2CaSO_4 \cdot \frac{1}{2} H_2O + 2H_2O \xrightarrow{\text{Hydration}} 2CaSO_4 \cdot 2H_2O$$

$$CaSO_4 + 2H_2O \longrightarrow CaSO_4 \cdot 2H_2O$$

Classification of Gypsum

Gypsum binders are classified according to burning varieties.

1- The low burning variety is manufactured by heating dehydrated gypsum to a temperature of about 160°C. The examples of low burning variety are building and extra strong gypsums.

2-The high burning (anhydrite) variety is obtained by burning dehydrated gypsum at 700°C–1000°C, when the chemically bound water is lost totally.

Gypsum may also be classified as:-

a- low strength gypsum—obtained by heating natural gypsum rock at normal pressure, the resultant gypsum (β modification) is very hygroscopic (60–65%) and porous (40%).

b- extra strong gypsum—obtained by heating gypsum at pressure of 2–3 atm followed by drying at 160°C–180°C (α modification). The extra strong gypsum is used in metallurgical industries for manufacture of molds.

Manufacturing of Gypsum

The excavated raw materials are crushed, and if the kettle process is used, ground until about 60 per cent pass No. 100 sieve. In the rotary process the final pulverization is omitted until calcination is completed.

1- The kettles employed for calcinations are 2.5 or 3 m in diameter and about 2 m high. The pulverized material is moved 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 sink. 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 calcite about 5 to 6 tons. The calcined product is then cooled partially in a vat and is sent to the screens. Residues from the screen are ground; the fines are stored in bins.

2- In the rotary process the raw material is crushed to pass through 25 mm mesh and is then fed into 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.

Plaster of Paris

It is produced by incompletely dehydrating pure finely ground gypsum at a temperature somewhat lower than 185°C. Most plasters theoretically approach ($CaSO4 + ½ H_2 O$) which contains about (6.2) per cent of water.

Properties of Gypsum as a Building Material

1-Fire Resistance of Gypsum

It is fire resistant in nature. They stop the chances of spreading of fire which ensure life safety. Now this resistance of gypsum against fire is due to the presence of water that is present within gypsum products. Say a gypsum plaster board of 15mm thickness would possess almost 3 liters of crystal water within it. When fire approaches the water, it undergoes evaporation resulting in a protective layer covering the gypsum product. This would help in stopping the spread of fire to further materials.

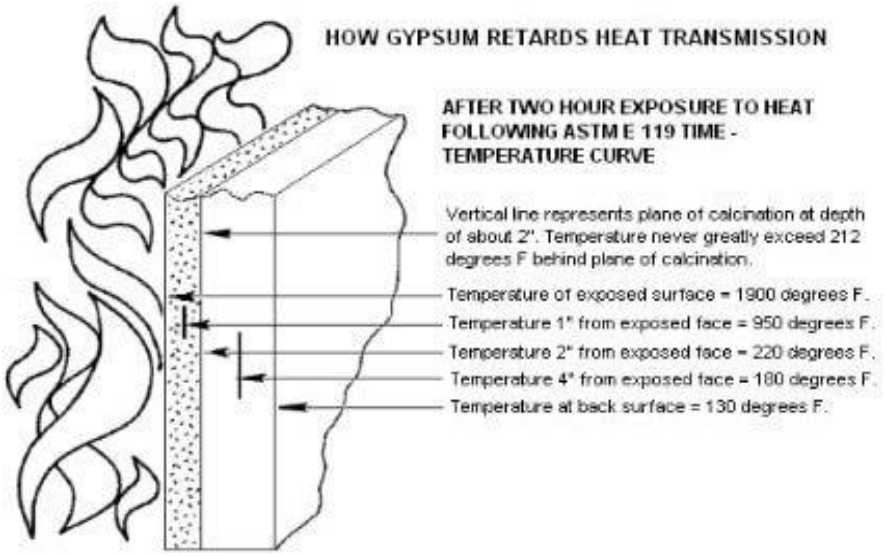

Figure: Fire Resistance Behavior of Gypsum

1- Acoustic Properties of Gypsum

Gypsum products are developed to focus more on sound insulation properties. Other methods like masonry would act well, which is commonly used in a higher thickness that now is found less demanding compared to gypsum. Gypsum plasterboard is specially designed for noise reduction and prevents reverberation. Incorporating an air space between two solid gypsum wall bring higher acoustic performances, by restricting the noise to pass through. For example, instead of a masonry wall of 110mm thickness, we can install a drywall of 75mm thickness to achieve same sound performance.

2- Thermal Properties of Gypsum

The thermal properties rendered by the gypsum construction would enable good balancing of indoor humidity and temperature. Gypsum construction incorporating cavities, like plasterboard or formwork construction with gypsum gives extra insulation properties.

Use of plaster boards in interior construction acts as a vapor barrier preventing indoor humidity.

1- Used for Plaster for Decoration – The combination of gypsum powder with water makes gypsum plaster that support the formation of beautiful aesthetically pleasing linings for ceilings or wall. They help in molding as well as shaping.
2- Used for walls and ceiling
3- Gypsum plaster Blocks used as partitions and as tiles
4- Used for self-leveling screeds
5- Fiberboard with Gypsum

Advantages of Gypsum as a Building Material

1- Delivers Smooth Surface – It is used as a plaster material if properly done would provide us with a smooth white finish, which is free of cracks as well as scars. This is a highlighting property when it comes to indoor finishing.
2- Balance Indoor Atmosphere – It is of natural origin. They have a natural capability of balancing the indoor climate as well as humidity.
3- It is environmental friendly
4- It is fire resistant in nature
5- It has high thermal and acoustic insulation
6- It provides good aesthetic and functional features – The creativity of architects is boosted by the incorporation of gypsum products, within the budget. It provides a variety of stunning design options.
7- Ease of Installation – Using gypsum products, for example, for an internal wall construction, we just need to fix the frame and fill up the joints. The full process is clean, easy and fast. Using gypsum plaster as a final finish reduces the work of additional painting. The white finish itself gives a clean appearance.
8- Variety of Gypsum Products – A large variety of gypsum products is available that meets several practical and aesthetic requirements. The choice of the right product is made with the help of unique packages that is given by the manufacturers with adequate technical assistance.

The major shortcomings are:

1- Its poor strength in wet state.

2- High creep under load.

Clay tile

Tiles are thin slabs of low melting clays used for various purposes in engineering constructions. These give a very pleasing appearance and good service properties. Roofing tiles, flooring tiles, wall tiles and partition tiles are some of the examples.

Manufacturing

Tiles are made in the same manner as bricks, but are thinner and lighter, so require greater care. These are manufactured from a clay mass with or without admixtures of coloring impurities by molding and subsequent burning until baked, up to about 1300 °C. The clay should be highly plastic with lean admixtures and fusing agents to lower the melting point. These are molded in machines of the auger or plunger type and are commonly burned in continues kilns.

Characteristics

Good tiles should have these properties

1. Uniform texture.

2. Accurate size and shape.

3. Free from defects like flaws and cracks

4. Water absorption (less than 15 per cent).

5. resistant to atmosphere and dampness.

6. Durability.

Testing of tiles

Flexural strength test

Consists of applying the load along the center line at right angles to the length of the tile (which has been immersed in water for twenty four hours) supported on the rounded edges of wood bearers. Six tiles are tested and the average breaking load should not be less than as specified in the code. The rate of loading is kept uniform and may vary in the range of 450-550 N/min.

Flexural strength (N/mm2) = 15 WS /bt^2

Where

W = breaking load, S = span in mm (3/4 of tile), and b, t = width and thickness, respectively.

Impact test

The apparatus for the impact test consists of an upright stand fixed to a heavy base. A steel ball 35 mm in diameter and 170 g in weight is held in jaws of a clamp fixed to the stand. Three specimen tiles are oven dried at a temperature of 100–110°C till they attain a constant weight and then allowed to cool at room temperature. The tile is placed horizontally with its face upwards over a 25 mm thick rubber sheet which in turn is placed over a rigid horizontal surface. The tile is so adjusted that the ball when released falls vertically on the Centre of the tile. The steel ball is first released from a height of 75 mm. Then the height of release is raised in steps of 75 mm until the test specimen fractures. The maximum height of release of the test ball is reported.

$G = \frac{V}{A}$ (J/m^2),

Where:

G: Impact strength

V: absorbed energy to break the sample

A: cross sectional area

$K = \sqrt{G * E}$ $(N.J/m^4)$,

Where:

K: factor toughness.

G: Impact strength.

E: modulus of elasticity.

Absorption test

Six tiles are dried in oven at 105 ± 5°C and cooled at the room temperature. They are then immersed in water for twenty four hours. Thereafter wiped dry and weighed.

Absorption in % = $\frac{W2-W1}{W1}$ X 100

Where,

W1: Dry weight of specimens.

W2: the immersed weight of specimens.