

# Study of Gypsum: Properties, Applications and Benefits

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## **ABSTRACT:**

Gypsum, a calcium sulfate dihydrate-based naturally occurring mineral, has drawn a lot of interest because of the wide range of sectors in which it is used. Gypsum provides nutrients to plants by supplying sulphur and calcium, with calcium aiding in nutrition absorption in the roots. Sulphur also increases agricultural productivity. It may help to ameliorate acidic soils. The application of gypsum plaster saves time, which reduces the project's cost. The amount of waste generated during application is small. It is simple to work with and produces a nice finish. Because gypsum plaster does not need to cure, it saves both water and time during construction. This chapter seeks to give an overview of the features of gypsum, investigate its many uses, and talk about the effects that its usage and manufacture have on the environment.

## **KEYWORDS:**

Gypsum, Gypsum Wall Plaster, Gypsum Plaster Boards, Hard Finish Plaster, Types.

## **I. INTRODUCTION**

Calcium sulfate dihydrate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) is the main component of the soft sulfate mineral known as gypsum. Due to its special qualities, it is frequently utilized in many different sectors and has a wide range of applications. We shall examine gypsum in depth in this essay, going into its origin, physical traits, applications, and environmental effects. Saline water evaporates and turns into gypsum. Gypsum deposits are left behind when water with a lot of dissolved calcium and sulfate ions evaporates. These deposits can be found as enormous layers in the earth's crust or as sedimentary rock formations. Gypsum may also be made artificially by precipitating calcium sulfate from a solution or by burning gypsum rock. Gypsum is a substance with a hardness of 2 on the Mohs scale and a white or colorless appearance. Since it is somewhat soft, a fingernail may be used to scrape it. Gypsum is distinguished by the unusual ability it possesses to partially dehydrate when heated by losing water.

Gypsum is transformed into calcium sulfate hemihydrate ( $\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$ ), often known as plaster of Paris, by a process known as calcination. Gypsum is used in many different types of businesses. Construction is one of the industries where gypsum is most frequently used. It is employed in the production of drywall, plaster, and other building products. Gypsum and water are combined to make a paste that may be shaped into different forms and solidified to create plaster. Drywall, often referred to as gypsum board or plasterboard, is frequently used for interior walls and ceilings in structures. It is manufactured by sandwiching a layer of gypsum between two sheets of paper [1], [2]. Gypsum is widely utilized in agriculture as well as in building. It is a great supplier of calcium and sulfur, two minerals crucial for plant development. Gypsum promotes nutrient availability for plants, minimizes soil erosion, and helps to improve soil structure and drainage. It is frequently used in agricultural settings to boost crop output and address soil deficiencies. Gypsum is used in a variety of fields, including industry, art, and medicine. It is utilized in medicine as a filler in dental products including dental impressions and casts. Gypsum is a material used in the arts for sculpting, molding, and making plaster castings. Gypsum is a filler used in paper, textiles, paints, ceramics, pottery, and other manufacturing processes. Gypsum has many useful applications, but its extraction and usage can have an impact on the environment. Gypsum mining and processing have been linked to habitat loss, water pollution, and land disturbance.

Ecosystems may be harmed since the extraction procedure requires removing the top soil and plants. Gypsum is frequently found in association with other minerals, such as limestone, which might cause the processing of the material to produce sulfur dioxide ( $\text{SO}_2$ ), causing air pollution. The negative effects of gypsum manufacturing on the environment have been attempted to be reduced. The negative consequences can be reduced by using best management methods, such as efficient mine reclamation, water treatment, and pollution control measures. Gypsum products may also be recycled and used again to cut down on waste and the need for new supplies. In

summary, gypsum is a versatile mineral with a variety of uses. It is used in a variety of industries due to its special qualities, such as its capacity to solidify when combined with water and then return to a powdery state when heated. Gypsum is used widely in a variety of industries, including building, agriculture, medicine, and the arts. To maintain sustainable practices, it is crucial to take the environmental effect of its extraction and usage into account and remedy it [3], [4].

**Types of Gypsum:** Gypsum comes in a variety of forms depending on its chemical and physical characteristics. Let's look at a few of the most typical types:

a. **Selenite:** Gypsum comes in a translucent or transparent variant called selenite. It often takes the appearance of fibrous aggregates or long, thin crystals. Selenite is a crystal that is frequently used as a healing stone and is recognized for having a glassy look [5], [6].

b. **Alabaster:** Alabaster is a fine-grained, often white or delicately tinted form of gypsum. Because it is softer than other varieties of gypsum, it is simple to carve into sculptures, ornaments, and architectural components. Alabaster has been employed in art and handicraft for many years.

c. **Satin Spar:** Gypsum that has a silky, fibrous texture is called satin spar, a kind of fibrous gypsum. In fibrous aggregates that may be polished to a satin-like shine, it is frequently discovered. Satin Spar is frequently used as a gemstone material and for ornamental uses.

d. **Desert Rose:** Gypsum that grows in dry desert areas is known as Desert Rose. It is made up of flattened crystals and has a characteristic rosette-like form. Sand-filled areas are where you may frequently find Desert Rose, which is utilized as a valuable mineral specimen [7], [8].

e. **Anhydrite:** A calcium sulfate mineral that resembles gypsum in many ways is anhydrite. It differs from gypsum in that its crystal structure doesn't include any water molecules. Anhydrite occurs in both sedimentary and volcanic contexts and is typically colorless or light gray. It serves as a drying agent and is used in the manufacture of cement.

f. **Plaster of Paris:** Gypsum that has been partly dehydrated through the calcination process is used to make plaster of Paris. When combined with water, it turns into a fine powder that may be used to make a paste. For purposes of casting, molding, and setting, plaster of Paris is widely used in building, fine art, and medicine [9], [10].

These are but a few illustrations of the different gypsum varieties. Gypsum comes in a variety of forms, each with distinctive looks, textures, and uses that make it useful in a variety of creative fields and sectors.

## II. DISCUSSION

**Gypsum Wall Plaster:** Gypsum plaster, commonly referred to as plaster of Paris or gypsum plaster, is a multipurpose material that may be used to cover walls and ceilings in both residential and commercial construction projects. Due to its special qualities and advantages, it has been utilized extensively for millennia. This essay will go into great detail on gypsum wall plaster, including its composition, methods of use, benefits, and potential downsides. Gypsum is a mineral that may be found in sedimentary rock formations, and it makes up the majority of gypsum wall plaster. Plaster is made from gypsum, a soft sulfate mineral that is crushed and processed into a fine powder. The powder is then combined with water to create a paste-like consistency that is used to paint ceilings and walls. It hardens into a smooth, enduring surface after drying. Gypsum wall plaster application is a multi-step process. The surface that will be plastered is first cleaned and ready. The surface is cleaned of any loose paint, dust, or debris, then moistened to improve adherence. The gypsum plaster is then applied by a plasterer using a variety of methods, including troweling or spraying. For a consistent finish, the plaster is spread uniformly and smoothed out. The plaster is then allowed to cure and set, which can take anywhere from a few hours to a few days, depending on the thickness and surrounding factors.

The simplicity of gypsum wall plaster's application is one of its many noteworthy benefits. It may be used on a variety of surfaces, including metal, wood, concrete, and brick. Due to its adaptability, it may be used for a variety of construction projects, including both residential and commercial buildings. Gypsum plaster is a common material for ornamental components like cornices, ceiling roses, and arches because it can be molded into elaborate forms. Gypsum wall plaster also has the benefit of being fire resistant. Gypsum is naturally incombustible; thus it doesn't aid in the propagation of fire. Gypsum emits water vapor when exposed to high temperatures, which aids in containing and containing the fire. Gypsum plaster is a great option for fire-rated assemblies and locations where fire safety is a concern because of its characteristic. Gypsum wall plaster also has

great sound-insulating qualities. Gypsum's porous nature absorbs sound vibrations, which lessens noise transfer between spaces or from outside sources. This makes it perfect for spaces like theaters, recording studios, and workplaces where acoustic control is crucial. Additionally, gypsum wall plaster has great thermal insulating qualities. It aids in controlling indoor temperatures by reducing the rate at which heat is transferred through walls and ceilings. As a result, gypsum plaster may help buildings be more energy efficient and spend less on heating and cooling.

Gypsum wall plaster does have a few downsides despite its numerous benefits. First off, because continuous contact to moisture might cause it to degrade, it is not recommended for rooms with high moisture content, such as bathrooms or kitchens. Such circumstances can call for the use of specific moisture-resistant plasters. Gypsum plaster's greater softness in comparison to other materials like cement is another drawback. If hit or handled roughly, it may be prone to chipping or denting. As a result, it might not be the greatest option for sites with frequent usage or where durability is a top priority. In conclusion, gypsum wall plaster is a flexible and popular building medium. It is a desirable alternative for covering walls and ceilings due to its composition, application options, and special qualities. Gypsum plaster has several advantages, including simplicity of use, fire resistance, sound insulation, and thermal qualities. It is crucial to take into account its drawbacks, such as its vulnerability to physical harm and susceptibility to moisture damage. In general, gypsum wall plaster is still a preferred material for producing visually beautiful and practical surfaces in a variety of architectural contexts.

**Hard Finish Plaster:** Hard finish plaster, often referred to as hardwall plaster or undercoat plaster, is a kind of plaster used in building to provide walls and ceilings a smooth, strong surface. Before the final ornamental treatments, like paint or wallpaper, are added, it is often used as a base coat. We shall examine hard finish plaster in-depth in this essay, going through its makeup, methods of use, benefits, and potential downsides. Gypsum, sand, and additives make up the composition that makes up hard finish plaster. The plaster's binding qualities and general strength are provided by the soft sulfate mineral gypsum. Sand is added to plaster to increase its hardness and endurance, while additives like fibers or polymers may be used to improve certain qualities like fracture resistance or workability. Hard finish plaster application is a multi-step process. The surface that will be plastered must first be cleaned and primed to remove all loose debris, dust, and other contaminants. To attain the correct consistency, the plaster is next combined with water in accordance with the manufacturer's recommendations.

Then, either a motorized plastering machine or a hawk and trowel are used to apply it to the surface. To produce a smooth and consistent finish, the plaster is distributed uniformly and leveled using a variety of methods, including feathering and skimming. Before the final ornamental finishes are put, the plaster must first dry and cure, which usually takes a few days. Hard finish plaster's durability and resistance to wear and tear are two of its main benefits. Hard finish plaster is tougher and more resilient than other varieties of plaster because it contains sand and other chemicals. This makes it especially appropriate for settings like corridors, stairwells, or commercial environments that see higher levels of impact or physical stress. Plaster with a hard finish can endure normal wear and tear and is less likely to chip or break. The capacity of hard finish plaster to provide a smooth and level surface is another benefit. It can successfully conceal flaws in the underlying substrate, such as tiny fractures or unevenness. This makes it a great option for remodeling or refurbishing tasks where a pristine finish is desired.

The smooth surface that hard finish plaster provides also makes it simpler to apply final decorative finishes, such as paint or wallpaper, producing an aesthetically pleasing and professional appearance. Hard finish plaster also has strong fire resistant qualities. The primary ingredient of plaster, gypsum, is naturally non-combustible and serves as a barrier to the spread of flames. When used in conjunction with other fire-rated construction materials, this can help increase fire safety in structures. Despite its benefits, there are certain things to keep in mind while using hard finish plaster. In order to guarantee strong adhesion and long-term performance, the surface must be properly prepared. Before applying the plaster, any debris or impurities should be taken care of, and the surface may need to be primed or sealed. Hard finish plaster should not be used in bathrooms or other wet rooms because of the high moisture content or direct water exposure. Specialized moisture-resistant plaster systems ought to be utilized in these circumstances. As a result, hard finish plaster is a dependable and long-lasting substance used in building to create supple and solid surfaces. It is appropriate for regions that need great durability and impact resistance because to its composition, application techniques, and physical characteristics. Hard finish plaster has a number of benefits, including its capacity to conceal flaws and its fire resistance. But it is crucial to take into account good surface preparation and its restrictions on moisture exposure. In both residential and commercial building projects, hard finish plaster is an important tool for producing finishes that are visually beautiful and long-lasting.

**Gypsum Plaster Boards:** Gypsum plasterboards, commonly referred to as drywall, plasterboard, or gypsum boards, are frequently used building materials for interior walls and ceilings. They are made out of a gypsum core encased in two sheets of paper or another type of face material. Gypsum plaster boards will be thoroughly discussed in this essay, including their composition, manufacturing process, installation procedures, benefits, and potential downsides. Gypsum, a mineral that occurs naturally and is processed into a fine powder, makes up the majority of the material in gypsum plasterboards. Gypsum powder and water are combined to create a slurry, which is then applied to an uninterrupted sheet of paper. To guarantee adequate adherence and thickness control, a further layer of paper is added on top, and the assembly is then run through a series of rollers. Before being baked in ovens or kilns to eliminate moisture and set the gypsum core, the boards are first cut into a variety of sizes and lengths.

Gypsum plasterboard installation is a multi-step process. The boards are first trimmed to size and fastened with screws or nails to the studs or structure of the wall or ceiling. To allow for expansion and contraction, the boards are positioned with a tiny space between them. After the boards are fastened, jointing compound and tape are used to strengthen the seams between them and provide a continuous surface. The boards can then be treated using a variety of methods, including sanding, painting, or applying ornamental finishes like wallpaper or skimming. Gypsum plaster boards have a number of benefits that make them popular in building. They first offer a rapid and effective solution to build internal walls or ceilings. The installation procedure is rather quick, especially when compared to more conventional techniques like wet plastering. Both building time and labor costs might be greatly decreased as a result. Gypsum plasterboards are very portable and simple to handle. They come in a range of thicknesses, from 9.5mm conventional boards to thicker alternatives for improved acoustic or fire resistant features. Gypsum boards are lightweight, which makes them easier to move about during installation and less physically taxing on installers.

Additionally, gypsum plaster boards have great fire resistant qualities. The inclusion of a gypsum core in the boards works as a fire barrier since gypsum is naturally non-combustible. Gypsum boards are therefore the perfect option for fire-rated assemblies and locations where fire safety is a concern. Gypsum plasterboards also offer strong thermal and acoustic insulation qualities. The gypsum core offers a certain amount of thermal resistance, which helps to control interior temperatures and increase energy efficiency, together with the air trapped within the board's structure. Gypsum's porous structure also helps to absorb sound, minimizing noise transfer between spaces or from outside sources. Gypsum plasterboards further offer a homogeneous, smooth surface for applying finishing finishes.

The interiors appear attractive and polished thanks to the paper facing on the boards, which makes it simple to apply paint, wallpaper, or other decorative materials. Gypsum plaster boards do have certain drawbacks despite their benefits. Since extended exposure to moisture might cause the boards to disintegrate, they should not be used in damp environments like bathrooms or wet rooms. Such situations call for the usage of moisture-resistant boards or specialist wet area solutions. Finally, gypsum plaster boards are a useful and adaptable building material that are frequently utilized for interior walls and ceilings. They are an excellent and affordable option for building enclosures and partitions because to their composition, manufacturing method, and features. Gypsum boards provide a number of advantages, including rapid installation, low weight, fire resistance, and thermal/acoustic insulation. However, it's crucial to take into account their moisture exposure restrictions and choose the right kinds of boards for particular applications. Gypsum plasterboards, which offer long-lasting and visually beautiful solutions for a variety of building projects, have essentially become a standard in the construction sector.

**Plaster of Paris and Stucco:** Stucco and plaster of Paris are two distinct building materials used for varied tasks. Despite sharing a gypsum foundation, their composition, application techniques, and ultimate look vary. We shall examine plaster of Paris and stucco in-depth in this essay, showing their similarities and distinctions as well as their traits and applications. Gypsum, a soft sulfate mineral, is the source of plaster of Paris, commonly referred to as gypsum plaster. Gypsum is heated to eliminate the water content and turn it into a fine powder, which is then used to make plaster of Paris. It creates a paste when combined with water that may be formed into many shapes. For making decorative features like sculptures, moldings, or ornamental patterns, plaster of Paris is frequently employed. Additionally, it is employed to patch up tiny holes or fractures in walls and ceilings. Plaster of Paris is applied by combining the powder with water to get a spreadable consistency. The paste is then applied using a trowel or spatula to the appropriate surface. It hardens into a solid substance and dries fast, often in a few hours. The smooth, white finish of plaster of Paris can be further sanded or painted for a polished look. The external plaster known as stucco, on the other hand, is often used to coat outside walls.

With the addition of chemicals or fibers to increase its strength and longevity, it is made out of a combination of sand, lime, cement, and water. Buildings have been decorated and protected with stucco for ages. It offers a weatherproof covering that can tolerate different climatic conditions. Multiple layers of stucco are applied to a building's outside surface during application. To provide a foundation for adhesion, a scratch coat rough layer is initially applied. The brown coat, which is a thicker coating that offers strength and stability, follows this. The stucco is then given a finish coat to give it its final look. Depending on the intended aesthetic, the final coat might be either smoothed or textured. Compared to plaster of Paris, stucco has a coarser texture, and the final look depends on the application method. It frequently appears in Spanish or Mediterranean-style structures, giving them a unique and rustic appearance. In conclusion, stucco and plaster of Paris are two distinct building materials. Gypsum-derived plaster of Paris is typically used for ornamental projects like sculptures or minor repairs. It is a white, smooth substance that dries rapidly and can be readily moulded. Contrarily, stucco is a combination of sand, lime, cement, and water that is used to coat external walls. It offers a protective and textured surface, which is frequently found in buildings with a Mediterranean flair. Both materials have distinctive uses and properties that meet various building requirements.

**Setting and Hardening of Gypsum:** Gypsum-based products, such as gypsum plaster or gypsum boards, rely heavily on the setting and hardening of gypsum, commonly referred to as the hydration process. When gypsum powder and water are combined, a chemical process occurs that turns the powder into a solid substance with useful qualities. We shall go into great depth about the gypsum setting and hardening process in this post. Gypsum goes through a number of steps before setting and hardening:

- a. **Mixing:** Gypsum powder is combined with water to create a paste-like consistency when mixing. The calcium sulfate hemihydrate ( $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ) in gypsum combines with the water to dissolve and create a fluid slurry.
- b. **Initial Set:** The calcium sulfate hemihydrate, generally known as gypsum, begins to re-crystallize when the gypsum slurry is stirred. Within a few minutes, the initial set happens, and it is distinguished by the start of the solidification process. The gypsum paste begins to thicken and lose its flexibility at this point.
- c. **Final Set:** Gypsum's ultimate set happens after the majority of the hemihydrate has crystallized as dihydrate. After mixing, this procedure usually takes 20 to 30 minutes. The gypsum paste gets firmer and less workable during the final set. When the paste achieves its stiffest and strongest state, the setting process is complete.
- d. **Hardening:** After the last set, the gypsum keeps hardening and becomes stronger. The calcium sulfate hemihydrate that is still unreacted slowly combines with water to form dihydrate crystals, which aids in the material's continued solidification. Gypsum continues to harden over the course of many days, getting steadily stronger and more resilient.

It is crucial to remember that a number of variables, including temperature, the proportion of water to gypsum, and the presence of additives, can affect how quickly gypsum sets and hardens. In general, the setting process is sped up at higher temperatures and slowed down at lower temperatures. The workability and setting time of the gypsum paste may be changed by adjusting the water-to-gypsum ratio. Gypsum-based materials' setting properties can be changed to meet the needs of a particular application by adding additives like retarders or accelerators. In conclusion, the chemical interaction between gypsum powder and water causes a fluid paste to solidify during the setting and hardening of gypsum. The first set happens soon after mixing, followed by the last set, during which the gypsum paste reaches its strongest point. In order to increase the material's strength and endurance, the unreacted gypsum continues to turn into dihydrate crystals, hardening the substance over time. When working with gypsum-based materials, understanding the setting and hardening process is crucial to getting the results you want in building applications.

**Effect of Heat and Moisture:** When employing gypsum-based materials in construction, it is essential to take into account how gypsum reacts to heat and moisture. When subjected to heat and moisture, the naturally occurring mineral gypsum, which is constituted of calcium sulfate dihydrate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ), goes through certain reactions and modifications. We shall look at how heat and moisture affect gypsum in this article.

- a. **Effect of Heat:** Gypsum goes through a process known as calcination when exposed to heat. Gypsum's chemically attached water molecules are forced out of the material during calcination, which creates calcium sulfate hemihydrate ( $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ ). Around  $150^\circ\text{C}$  ( $302^\circ\text{F}$ ) is the temperature at which this activity takes place. When gypsum is calcined, Plaster of Paris, a fine white powder that easily rehydrates back into gypsum when combined with water, is created. In building, plaster of Paris is frequently used, especially for creating molds, casting objects, and making minor repairs. It is crucial to remember that prolonged exposure to heat can

alter the structural integrity and strength of gypsum-based products. Products made of gypsum may suffer irreparable damage and lose their original qualities if heated past the calcination threshold.

**b. Effect of Moisture:** Gypsum has a high affinity for water. When in contact with moisture, it quickly absorbs water molecules and transforms back into calcium sulfate dihydrate (gypsum), its natural state. Rehydration or setting is the term for this action. Gypsum powder is mixed with water to make a workable paste for building applications like gypsum plaster or gypsum boards. Gypsum paste begins to set and solidify when it is applied to walls or ceilings because of the rehydration process, which turns the calcium sulfate hemihydrate back into gypsum crystals. Gypsum materials need a moderate quantity of water for appropriate setting and hardening, but too much moisture can cause problems including extended setting periods, decreased strength, and even the possibility of mold development. To obtain the desired uniformity and performance of the gypsum-based products, it is crucial to properly balance the water to gypsum ratio during mixing. In conclusion, gypsum-based products are significantly impacted by heat and moisture. Gypsum can be calcined by heat, turning it into Plaster of Paris, and it may be rehydrated by coming into touch with moisture, restoring it to its original state. Gypsum-based products must be applied successfully in building projects by having the effects of heat and moisture properly understood and under control.

### III. CONCLUSION

Gypsum is a precious mineral with special qualities that make it useful in a variety of applications. Its broad application in fields including construction, agriculture, and industry is likely due to its vast availability, low cost, and ecologically beneficial features. Gypsum has been a popular option for a variety of building supplies and construction materials due to its capacity to increase soil fertility, strengthen fire resistance, and offer sound insulation. However, it's crucial to take into account how producing gypsum affects the environment. Gypsum may be extracted and processed in a way that disturbs the environment and uses energy. To reduce these effects, appropriate management and mitigation strategies should be put in place. Gypsum waste may also be recycled and used again, which can lessen the gypsum industry's total environmental impact. In conclusion, gypsum is a versatile mineral that is essential in a wide range of uses. We can take use of the advantages of gypsum while reducing its negative effects on the environment by comprehending its qualities, looking into sustainable manufacturing techniques, and encouraging responsible use. Gypsum-related technologies must continue to undergo research and innovation if they are to be used sustainably in the future.

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