Vermiculite Gypsum Plasters

Vermiculite plasters can be made with either gypsum or Portland cements This specific information leaflet looks at gypsum-based plasters. Vermiculite plasters typically comprise a relatively simple mixture, usually a factory made pre-mix of the hydraulic binder (in this case hemi-hydrate gypsum), the exfoliated vermiculite aggregate, potentially other aggregates such as perlite, fillers, retarders and any specific additives as required by the final service requirements.

All gypsum plasters are vulnerable to moisture. They can have a porosity over 50 percent by volume. So, all gypsum-based plasters are unsuitable for external applications, or for internal applications where excessive dampness occurs. Prolonged or repeated exposure to moisture can cause loss of strength in the plaster and loss of adhesion to the substrate.

Picture shows a plasterer covering a wall, using a traditional plasterer's hawk (in his left hand) and applying the plaster off the hawk onto the wall with the trowel.

Advantages of Vermiculite Plasters Over Conventional Plasters:

Improved coverage

Weight for weight, a vermiculite plaster can cover a greater area when compared with plasters using denser aggregates, such as sand.

Lightweight

The dry weight of placed vermiculite plaster is less than half that of traditional sanded plaster. The lighter weight makes the vermiculite plaster easier to carry, mix and apply.

Adhesion

Adhesion is an exceptional feature of vermiculite plasters. Not only can they be used on all normal backgrounds but they can also be applied directly to concrete in a way that is not possible with any other types of plaster. Hacking of the surface or the use of a special bonding agent is not necessary, providing that the concrete is clean and free of mould release oil or paint. However, certain concretes with a very high suction may require treatment with a bonding compound. Generally, adhesion is improved by wetting the clean concrete prior to plastering.

Resistance to cracking

Due to vermiculite's ability to absorb local stresses, the cracking normally associated with conventional sanded plasters is minimized. After application, vermiculite plasters are exceptionally stable within wide atmospheric limits. Vermiculite plasters will also normally accept nails and screws without cracking or spalling. The enhanced spall resistance of vermiculite plasters is due to the ability of the vermiculite particles to accommodate dimensional change.

Workability

Vermiculite plasters retain their fattiness, even on high suction backgrounds, and can be easily worked. They accept all normal types of decoration.

Thermal conductivity

Vermiculite plasters have as much as two to three times the insulating capacity of traditional plasters. This feature, combined with their low thermal capacity, reduces the rate at which heat is lost (or gained) through walls and ceilings, and enables comfortable living and working temperatures to be reached quickly. This is particularly important in rooms that are only used intermittently. In addition, pattern staining caused by heat loss through the ceiling is eliminated.

Typical Thermal Conductivitys of Various "Plaster" Formulations

	Density		Thermal Conductivity	
	kg/m³	lb/ft³	W/m °C	Btu in/ft²h °F
Sand, lime and cement plaster	1,440	90	0.476	3.3
Sand and gypsum plaster	1,410	88	0.649	4.5
Gypsum plaster	1,280	80	0.461	3.2
Vermiculite gypsum plaster	640	40	0.187	1.3

Typical Thermal Conductivity's of Vermiculite Plasters of Differing Densities

Density		Thermal Conductivity	
kg/m³	lb/ft³	W/m °C	Btu in/ft²h °F
448	28	0.108	0.75
480	30	0.130	0.90
640	40	0.187	1.30
768	48	0.202	1.40

Strength

Vermiculite plasters are tough and resilient, not hard. They will indent under impact without losing bond rather than crack and fall away. The strengths of vermiculite base coat plasters are lower than denser sanded plasters, and slightly lower than the perlite containing "brown" coat plasters. Therefore, it is important that proper gradation and proper proportioning be rigidly followed. In addition, a greater amount of mixing water is used and care must be taken to allow excess water to evaporate.

Anti-condensation

As the surface of vermiculite plaster closely follows the temperature of the atmosphere, the risk of condensation is reduced. Spray applied plasters, which leave an open textured finish, have been particularly successful in atmospheres of high humidity, such as encountered in breweries, kitchens swimming pools, etc. Although, using a hydraulic Portland cement rather than gypsum as a binder is generally more advantageous long-term for high humidity environments.

Vermiculite plasters can be applied by hand or with a spraying machine. Being a non-abrasive aggregate, vermiculite is well suited to spray application. Sprayed plasters can have an attractive decorative appearance.

Vermiculite can also be combined with other aggregates such as perlite to produce differing desired properties in low density plaster formulations.

Acoustic plasters provide reverberation (echo) control by the physical mechanism of absorbing sound energy and converting it into heat.

Vermiculite-based plasters used in the construction industry can be batched on site by adding the exfoliated vermiculite and water to a suitable hemi-hydrate gypsum material, or more commonly factory-made pre-mixes are simply mixed with water on site and applied. These can be applied using either more traditional hand tools such as "hawk and trowel" or by the use of pumping and spraying machinery. These plasters can be applied to a variety of substrates including: concrete, blockwork, cement renders, other plasters and expanded metal laths.

South Guangzhou Railway Station: Class A fire-rated vermiculite panel attached on the ceiling for both decoration and fireproof features.

Photo courtesy of Luyu Royal Gold Building Material

What is gypsum?

Pure gypsum is a white rock. Sometimes impurities discolor it grey, brown or pink. Its scientific name is calcium sulphate di-hydrate and its chemical formula is $CaSO_4.2H_2O$. This means that, for every molecule of gypsum, there are two molecules of water. This is an important fact in the story of gypsum. If a portion of gypsum rock is ground to powder and heated to around 150°C (~300°F), it loses about three quarters of its combined water. In this dehydrated form, it is known as hemi-hydrate gypsum plaster of chemical formula $CaSO_4.0.5H_2O$, which we commonly refer to as "Plaster of Paris." If this de-hydrated gypsum powder is then mixed with water, this paste or slurry will set rock hard. The chemically-combined water, previously removed, has re-combined, and the material has reverted to the original composition of the gypsum rock.

$CaSO_4 \bullet 2H_2O$ + heat → $CaSO_4 \bullet 0.5H_2O$ + $1.5H_2O$ (released as steam)

The setting of unmodified (un-retarded) plaster starts about 10 minutes after mixing and is complete in about 45 minutes; but not fully set for 72 hours.

For centuries, gypsum has been known as a building material. The earliest recorded use of gypsum as a building material was in Anatolia in Turkey in around 6000 B.C. Later, around 3700 B.C., it was used on the interiors of the great pyramids in Egypt on which artists painted magnificent frescoes. The Romans used mixtures of lime and sand to build up preparatory layers over which finer applications of gypsum, lime, sand and marble dust were made; pozzolanic materials were sometimes added to produce a more rapid set.

While gypsum plasters continued to be used, their widespread use in Europe was generally overshadowed by lime based plasters. In the mid-19th century, Portland cement based plasters became commonly available and plasters and renders using this hydraulic set cement binder became commonly used.

Plaster of Paris is referred to as an un-retarded plaster. It sets too quickly to be useful in most applications especially for plastering. Setting times for gypsum plasters are lengthened by adding suitable retarders to produce useful "retarded hemi-hydrate plaster."

In the United Kingdom, widespread use of gypsum plasters staretd occurring in the 1930s. Within a few years, more modern lightweight plasters containing vermiculite (replacing sand as an aggregate) were being introduced. By the 1960s the more traditional 1:1:6 (cement: lime: sand) plasters were being replaced by the quicker setting gypsum plasters.

Photograph showing wet plastering by means of 'floating' the brick or blockwork wall with an undercoat plaster such as a "bonding-coat" containing vermiculite aggregate, using a hawk and trowel application. This can be ruled with a straight-edge to give a flat surface before skimming with finish plaster.

Gypsum Basecoat Plasters: General

Gypsum basecoat plaster is defined as that portion of the plaster coat which is applied to lath or masonry substrates, and which supports the final finish coat. It is used to fill in whatever additional thickness is required to square a room and provide a true surface for a monolithic finish.

The base coat is the most important element of a plastered surface. It supplements the strength of the plaster base to provide resistance against minor structural movements which is aided by the addition of vermiculite.

Typically, a vermiculite containing base coat or bonding coat is designed to be an undercoat plaster for use on low suction backgrounds, e.g. some brickwork, stonework, blockwork or concrete, plasterboard (sheet-rock), expanded metal lath, or surfaces treated with bonding agents, such as PVA.

Although the main use of vermiculite in this area of application is related to factory-made premixes, there continue to be occasions where vermiculite is used as an aggregate in site-prepared mixes. The following mixes are recommended for normal purposes, but both richer and leaner mixes may be used to meet special requirements.

Undercoat: 1-2 volumes of exfoliated vermiculite (Fine or Superfine Grade); 1 volume gypsum plaster.

Finishing coat: 1 volume exfoliated vermiculite (Superfine Grade); 3 volumes gypsum plaster.

It is recommended that no more than 2 cubic foot [57 litres] of vermiculite aggregate be mixed with each 100 pounds [45 kg] of hemi-hydrate gypsum plaster for most types of work, except for:

a) Plastering over unit masonry, or,
b) "Brown" coat plastering (three-coat work), where the total plaster thickness is 1 inch (25mm), or greater.

For these two exceptions only, the proportions should not exceed 3 cubic foot [86 litres] of vermiculite aggregate per 100 pounds [45 kg] of hemi-hydrate gypsum plaster.

Notes: "Brown-coat" is a traditional plastering term to denote a coat of plaster directly beneath the finish coat. In two-coat work, "brown-coat" refers to the basecoat plaster applied over the lath. In the three-coat work, the "brown-coat" refers to the second coat applied over the first "scratch coat" plaster. "Brown-coat" plasters are generally applied with a fairly rough surface, to receive the finish coat.

Specific "brown-coat" plasters, such as "browning coat" plasters formulated with perlite rather than vermiculite, are generally more applicable for higher suction backgrounds such as porous aerated concrete lightweight blocks, or the older "coke/breeze" blocks, certain brick surfaces and when covering tiled surfaces.

As indicated earlier in this information leaflet under Strength the proportioning of aggregate volumes to plaster volumes exerts a significant influence on the final plasters performance. So, the adherence to the recommended proportioning cannot be over-emphasised whether, the aggregate be vermiculite, sand or perlite.

Typical Mechanical Strengths of Vermiculite Plaster Mixes

Proportions Gypsum to vermiculite aggregate	**Density** **lb/ft³ [kg/m³]**	**Compressive strength** **(lb/in²)**	**Tensile strength** **(lb/in²)**
1:2	50 – 55 [800 – 880]	400 – 525	130 – 160
1:3	42 – 45 [670 – 720]	250 – 325	70 – 100

Is vermiculite used in one coat, two coat or three coat plastering techniques?

There isn't really a definitive answer to this question. Some of this is dictated by local traditional techniques, and some is by the availability of propriety pre-mixed plasters. You can find one coat propriety pre-mixed plasters containing vermiculite in some parts of the world, but generally it is more common to find vermiculite being used either as an aggregate in the base-coat or "bonding coat" of a two coat system. But, in UK building practice there are propriety pre-mixed plasters that have vermiculite aggregate in both the base-coat and finish-coat of the two coat systems. Not surprisingly, the volume of vermiculite aggregate in the final finish coat is less than in the base coat, so as to allow for finer finishing of the plaster to receive the final decorative finish.

Typical coverage of vermiculite containing plasters

The following coverages have been abstracted from the technical literature of a manufacturer of a UK propriety brand of vermiculite containing base-coat plaster known as a "bonding-coat" and a finish coat plaster also containing vermiculite.

Substrate	Recommended coat thickness (mm) [inches]	Approximate coverage (m^2/1000 kg) [ft2/2000 lbs]
Gypsum wall board	8mm [5/16th]	135 – 150 [1320 – 1465]
Dense aggregate concrete block	11mm [7/16th]	100 – 115 [976 – 1120]
Precast concrete units[1]	8mm [5/16th]	135 – 150 [1320 – 1465]
Expanded metal lath[2]	11mm [7/16th]	135 – 150 [1320 – 1465]

Notes: [1] Propriety bonding agents may be required
[2] From face of lath.

General notes on background preparation when plastering

Surfaces should be reasonably dry, clean and protected from the weather, and suitable for the chosen specification.

In addition, before plastering concrete backgrounds, ensure that any mould release oils or other agents present on the surface are removed. Normal aggregate concrete should be given sufficient time to cure and mature before applying any plaster. Plasters should not be applied onto any "green" backgrounds, or where any free water is visible. Fully cured and mature concrete will require wetting to displace any air before plastering. Clean fresh water should be applied 5 – 10 minutes before the plaster is to be applied to control the suction. Pre-cast or in-situ concrete which is exceptionally smooth or which is made from limestone, brick, granite or many lightweight aggregates will normally require the pre-treatment with a propriety bonding agent. No-fines concrete normally does not need require wetting prior to plastering.

General note on vermiculite plasters

Vermiculite plasters, whether gypsum or cement based can normally be applied by hand (as described above), or by spraying machine, being a non-abrasive aggregate, vermiculite is well suited to spray application. In its widest sense the term "plasters" can refer, as in Continental Europe, to any coating product that when the components are mixed with water on site, and prepared for application to surfaces such as walls, ceilings, beams or columns. However, in this information leaflet the scope has been confined to gypsum based plasters and for regular constructional usage. Fire protection "plasters" with a gypsum binder are also a great consumer of vermiculite, but they are out of the scope of this specific information leaflet.

Acoustic plasters

Spray-applied premixed preparations of exfoliated vermiculite and hydraulic binders such as gypsum have been developed to provide a decorative acoustic plaster with a proven history of successful sound control. For ceilings such a plaster presents an unbroken soffit as an alternative to the repeated pattern of a panelled ceiling.

Acoustic plasters provide reverberation (echo) control by the physical mechanism of absorbing sound energy and converting it into another energy type (heat).

In the book titled: VERMICULITE by Dr. E.R. Varley (1952), the acoustic properties of a propriety vermiculite plaster on sale in the UK at the time when applied to a thickness of 5/8th inch (16mm) is described:

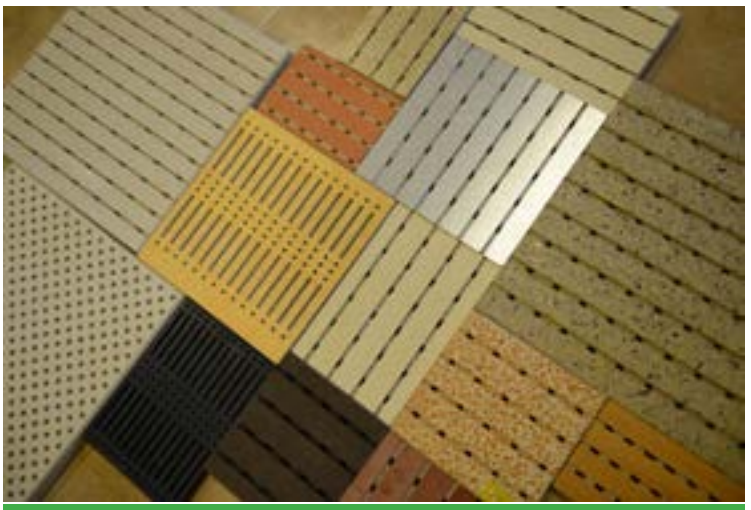
Frequency *Cycles per second*	**Transmission Loss** *decibels*
128	31.8
256	34.8
512	36.1
1024	37.2
2048	38.7
Average	**35.7**

The plaster mix above consisted of fine-mesh vermiculite mixed with fibred gypsum and hydrated lime in the ratio of 3 cubic foot of vermiculite (86 liters) to one hundred weight (51 kg) of gypsum.

Mixing

Gypsum plasters should be mixed by adding clean water using clean mixing equipment. Contamination and set material from previous mixes can adversely affect the setting time and strength of the plaster. Fresh contamination has more effect than old, so equipment should be washed immediately after mixing.

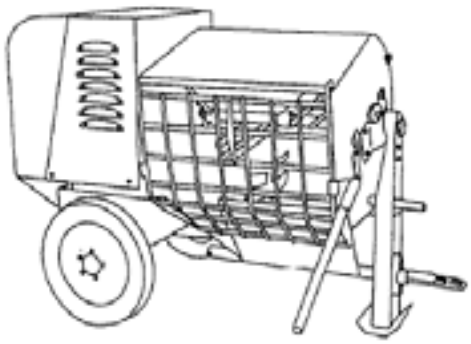
Vermiculite plasters are often mixed by hand or a mechanical whisk of a slow speed, high torque type. High speed or over long mixing that breaks down the vermiculite aggregate should be avoided. While mechanical mixing speeds the mixing process up, there is no need to continue mixing after the pre-mix has been adequately dispersed and a suitable consistency has been achieved. Over-mixing should be avoided as it leads to densification, deterioration in workability, and creates difficulty in achieving flat finishes as well as wasting time and energy.



Acoustical Vermiculite Panel: Class A fire-Rated with NRC (Noise Reduction Coefficient) values as high as 0.80

Photo courtesy of Luyu Royal Gold Building Material

Concrete block wall ready for plastering



Large mixer of a ribbon blade or paddle blade with a low speed, high torque design like the one pictured here are normally suitable for mixing vermiculite plasters for large jobs.

Plastering onto solid backgrounds

Base-coat plasters such as those containing vermiculite aggregate should be applied with firm, but not excessive pressure, and built out to the required thickness progressively. They should be ruled out to an even surface, but not polished with the trowel. They should be then lightly scratched to form a key for the finish coat plaster chosen.

Plastering onto metal lath

Application to expanded metal lath normally involves a three coat system that requires a pricking-up coat, which should be forced through the metal lath to obtain a good key. Normally, the surface of the pricking-up coat must be wire-scratched to provide a good key for the floating coat, and allowed to set but not dry, before a further floating coat of the same plaster is applied up to a maximum plaster thickness of 25mm (1 inch). Each coat needs wire-scratching in-between. The final floating coat should be ruled to an even surface and then lightly scratched to form a key for the final finish coat plaster application.

The use of vermiculite as an aggregate in gypsum plasters for sculpting

Plaster sculptures can be made either by carving a precast block of vermiculite plaster or by direct casting into a mould.

Plaster and vermiculite carvings:

Process: Subtractive Plaster Carving

Subtractive process - Process in which a three-dimensional form is created by removing, cutting away, or carving out unwanted materials.

Process:

1. Mix plaster, vermiculite and water according to these ratios: 3 parts vermiculite, 1 part plaster and approximately 2 parts water. Mix the dry ingredients together in a large bowl or other suitable container.
2. Add the water and let sit until it stops bubbling (1-2 minutes). Mix well with hands, squeezing out all the lumps.
3. After mixing, immediately pour into moulds and tap the sides of the mould to bring air bubbles up to the top.
4. Allow to harden (at least overnight) and cover moulds with plastic bags to keep fresh until ready for use.
5. When the mixture has hardened, carefully remove mould.
6. As the material is very soft and will still be very damp, a plastic or metal knife is a good carving tool. When the work is finished for the day, return it to the plastic bag to keep it moist until the next class period.
7. Students may carve by setting the block inside a shallow box to contain the mess. Carved material can be disposed of, or modelled into another project.
8. Once the desired shape is achieved and the remains and dust have been cleared, allow to dry. This may take several days depending on the humidity and heat. Work will become lighter in color and weight and will no longer feel damp.
9. When dry, seal with one or two coats of acrylic sealant and mount, if desired, to a wooden base.

Lightweight plaster castings:

There are occasions when a lower density plaster mix is needed for casting certain items such as sculptures which would otherwise be too heavy when cast with plain "Plaster of Paris" or fine casting plaster. In instances such as these, lightweight aggregates such as exfoliated vermiculite may be added.

US Patent 3,007,803 Titled "Casting Plaster" dated November 7, 1961 describes an interesting vermiculite plaster mix designed for the production of easily removable cores in the glass fibre lamination industry.

"The present invention relates to casting plaster for cores and more particularly to a casting plaster that can be quickly set for use and that can quickly disseminated, or, more specifically, quickly dissolved. Specifically the present invention is highly useful in the laminated fibre glass industry where fibre glass is applied to cores and cured thereon.

The present invention contemplates a casting plaster formed of expanded vermiculite, commercial casting plaster using gypsum, and a suitable commercial modelling clay, chine clay or bentonite. The vermiculite may be used in various granular forms……."

"This mixture may be of the following proportions by volume: Expanded vermiculite 7 to 13 parts, commercial casting plaster 7 to 13 parts, and approximately one part of suitable commercial molding clay."

In regards to mixing and curing the Patent describes the following:

"After the expanded vermiculite, casting plaster and modelling clay are thoroughly mixed in a dry state; it is then wetted and formed into a core of the desired shape. The core is then permitted to set, which requires between twenty or t hirty minutes, depending upon the size and thickness of various parts of the core. The core should then be heated to between 300 degrees to 500 degrees F., for from two to five hours depending again on the size, thickness and degree of dryness desired in the particular type of mold."

The cited advantages of this type of product being:

"The core thus formed is approximately one-third as heavy as other casting plaster heretofore used for cores, such as plaster of Paris. Obviously, being light in weight, it can be handled more readily…."

"A remarkable advantage of the present mix lies in the fact that the core made therefrom can be readily disseminated by disolution in water. The mix is highly soluble in water and when do dissolved it readily disseminates……."

Presumed mechanisms for the function of this invention:

It is presumed that the combination of the mixing of plaster with a lightweight aggregate such as vermiculite and modelling clay, and then the high temperature curing process (which must partially or even fully dehydrate the di-hydrate gypsum in the cured mix), must sufficiently weaken the core so as to allow it to be easily be removed by soaking in water.

Health & Safety considerations when working with vermiculite plasters

The Vermiculite Association always recommends safe working practices in the workplace.

In respect to vermiculite gypsum plasters the most important hazards and how to avoid problems are:

- **Gypsum plasters may form an alkaline solution on contact with moisture from the body and when mixed with water.**
- **Dust from mixing or working with plasters may irritate the respiratory system, skin and eyes.**
- **Avoid creating dust, and use appropriate personal protective equipment.**
- **Prevent plaster from contaminating drainage systems.**
- **Use appropriate lifting techniques when handling bags of plaster and mixing equipment.**
- **Seek full H&S information and Safety Data Sheets for all the ingredients used in the mixing of vermiculite plasters from the suppliers.**