Vermiculite Concrete

Introduction

Vermiculite concrete is a low density non-structural construction product. It is insulating (both thermally and acoustically) and intrinsically fire resistant. It is normally made simply by mixing exfoliated vermiculite as the aggregate, with cement and water, plus additives such as plasticisers if required.

The ratio of exfoliated vermiculite aggregate to cement and the vermiculite grade can be varied to the properties such as strength and insulation as required for the concrete. The applications for vermiculite concrete are however, all non-structural. Vermiculite concretes can also be produced containing other lightweight aggregates, such as expanded perlite, to give differing physical properties.

Normally the type of cement used in these mixes is Ordinary Portland Cement (O.P.C), although a higher initial strength may be obtained using Rapid Hardening Portland Cement (R.H.P.C).

For high temperature refractory applications, high alumina (luminate in the USA) cements may be used with great success to manufacture lightweight *in-situ* cast insulation mixes and back up insulation products. However, these applications are beyond the scope of this specific application note.

Applications for Vermiculite Concrete

The principal applications for vermiculite concrete are for *in-situ* site mixed applications such as:

- Floor and roof screeds
- Void filling insulation mixes around chimneys, back boilers and fire backs
- Blocks and slabs
- Swimming pool bases [see separate application note for this application]

Vermiculite concrete can be easily cut, sawed, nailed or screwed.

The lower density vermiculite concrete screeds are usually covered with a denser topping mix of 4:1 or 5:1 sand to cement mix to a minimum depth of 25mm (1 inch); the screed and denser more load distributing topping should ideally be laid monolithically to prevent dis-bonding and shear fracturing between the screed and the topping. Alternatively, an unbound topping of 50mm (2 inches) or more, can be used.

Typical Physical Properties of Vermiculite Concrete

Vermiculite: Cement Ratio (by Volume)	Air Dry Density kg/m^{-3} * [P.C.F]	Minimum 28-day compressive strength ($N\ mm^{-2}$)	Thermal Conductivity † ($Wm^{-1}\ °C^{-1}$)	Drying Shrinkage (%)
8:1	400 [25 lb/ft^3]	0.70	0.09	0.35 to 0.45
6:1	480 [30 lb/ft^3]	0.95	0.11	
4:1	560 [35 lb/ft^3]	1.23	0.16	

*Low density = 320 – 800 kg/m^{-3} [P.C.F] = Pounds per Cubic Foot (lb/ft^3)

† Thermal insulation: (k) = 0.086 to 0.234 $Wm^{-1}\ °C^{-1}$

Note: The thermal insulation value is a function of bulk density and particle size; generally the lighter the mix the greater the thermal insulation will be. When the same volume of different grades of exfoliated vermiculite are incorporated into a standard mix, the final density (and therefore, the thermal insulation) will be influenced by the fact that the finer grade of the vermiculite used the denser the product will be. Conversely, a mix based on coarse and mid-sized exfoliated vermiculite will generally have the same thermal insulation value at ambient temperatures, but, at elevated temperatures the finer particle size aggregate concrete will be more insulating due to a lower thermal diffusion.

Drying and Ventilation of Vermiculite Concrete and Screeds

Some special considerations regarding the use of vermiculite concrete should be kept in mind. Moisture entrapped in a roof such as constructional water, rainwater, or condensation is a potential source of problems such as blistering and ceiling staining. But more importantly, it will also detract from the design insulation value of the installation. Consideration therefore should always be given to measures which allow the free water or moisture to escape. Suitable measures include drilling of the roof slab at low points, the installation of ventilators in the asphalt or felt roofing and the complete venting of the screeds by means of ducts and suitable ventilators.

Special Uses of Vermiculite Concretes

The fireproof and insulating properties of vermiculite concrete make it ideal for use around flue linings, behind fire backs and around pipes when fitting room heaters. In residential/domestic chimneys, vermiculite concrete mixes can be used for extra insulation between brickwork flue and liner. For this application a 6:1 mix is normally used.

When radiant heating pipes are laid in buildings they may be placed on top of a vermiculite concrete screed before being embedded in dense concrete, thus ensuring the maximum transmission of heat to the room with minimum downwards heat loss.

Vermiculite concrete normally compresses up to 35% without disintegrating. This property has been utilized in underground mines where vermiculite concrete has been used to infill cavities and to build ventilation walls. These walls deform and compress without shattering when under pressure from the surrounding strata.

Floor and Roof Screeds

Vermiculite concrete screeds are light, insulating and intrinsically fire resistant. They are simply made by mixing exfoliated vermiculite aggregate with Portland cement and water.

a. Floor Screeds

Vermiculite floor screeds are widely used in single and multi-story buildings. On ground floors they provide excellent thermal insulation, while on intermediate floors, they reduce transmission of airborne sound. They can also be used industrially for insulation under furnaces and ovens, as well as providing insulation under cold stores.

These screeds are normally laid 50mm (2 inches) to 75mm (3 inches) thick, and should not be less than 32mm (1 ¼ inch) thick. In order to provide a suitably abrasion and wear resistant surface on which the floor finish can be laid, the screeds are normally covered with a denser topping layer comprising of a sharp sand and cement mix. This denser topping layer distributes floor loadings and prevents surface damage and abrasion. For most applications, the topping mix should consist of 65mm (2 ½ inches) of 1:4 sharp sand/cement by volume screed laid over the set vermiculite concrete. This will be self-supporting. Alternatively, a monolithic screed layer can be applied which requires that within an hour of the vermiculite concrete being laid, a cement grout is brushed into the vermiculite concrete followed by a minimum thickness of 15mm (9/16th inch) and a maximum of 20mm (¾ inch) of a sand/cement topping. This system relies on the screed and topping bonding and drying together to provide mutual support. Great care must be taken to ensure this bonding is achieved. Due to different drying/shrinkage rates, toppings of between 20mm (¾ inch) and 50mm (2 inches) are unlikely to be satisfactory. The thicker topping system is generally used for non-domestic applications where higher load-bearing and resilience is required.

Vermiculite concrete screeds do not normally require expansion joints, but should be laid in alternate bays of no more than 11 – 14 square meters (118 – 151 square feet), according to standard practice.

The vermiculite concrete floor screed normally consists of 6 parts vermiculite to 1 part Portland cement **by volume**. The vermiculite screed should be mixed and laid using the manufacturer's recommendations. After the topping has been applied the screed should be allowed to dry out thoroughly before application of subsequent floor finishes.

Photo: The Strong Company, Inc.

b. Roof Screeds

Vermiculite concrete roof screeds are specified for the insulation of flat, low pitched and shell roofs. They are used to conserve heat in winter and keep the building cool in summer, and reduce structural movement in the roof caused by solar heat.

Roof screeds offer many advantages:

- Roof screeds offer improved insulation of the building and conservation of heat.
- They assist in keeping the building cool in summer, and reduce the structural movement caused by solar heat penetration.
- Vermiculite concrete roof screeds can be readily laid to falls to provide a means of drainage on flat roofs since the screed is low in density (roughly one fifth of the weight of normal concrete). There is no significant effect on the dead weight of the building.
- Roof screed thickness may be varied as required to assist in re-grading to prevent "ponding" on flat roofs. This is of particular importance in the renovation of old roof structures.
- Vermiculite concrete roof screeds provide a permanent non-warping base for all surfacing materials.
- Screeds can be mixed onsite, and laid without any special equipment.

Vermiculite concrete roof screeds are suitable for concrete flat slab, low pitched and barrel vault roofs, and those constructed of wood wool slabs, hollow tile or pre-cast concrete beams.

Vermiculite concrete roof screeds should be protected with a minimum of 13mm (½ inch) sand/cement topping before the application of surfacing materials.

c. Ventilation of Roof Screeds

Moisture entrapment in a roof is always a potential source of trouble. All insulation screeds of this nature require ventilation to prevent blistering and staining of the ceiling caused by condensation or other water entrapment within the screed.

Various types of ventilators, which can be incorporated in asphalt and felt roofing to permit drying of the screed without delaying application of the roof finish, are normally used. If brick ventilators are used it is preferable to build in the ventilator before laying the asphalt. It is possible to lay a brick ventilator afterwards by cutting away the existing asphalt and sand/cement topping and "dishing" the vermiculite screed. As a rough guide, one ventilator for every 70 to 80 square meters (755 – 860 square feet) of roof is normally recommended.

Copper or other metal ventilators allow the relief of pressure from moisture vapor. They can be installed in connection with mastic asphalt or built-up felt roofing and should be installed at the higher parts of the roof or around the perimeter. The sand/cement topping over the vermiculite screed should be cut away and the screed "dished." When built-up roofing is used, the lower layers should be "frame-bonded" in order to allow the moisture vapor to flow along to the ventilators.

d. Mixes for Floor and Roof Screeds

The following mixes by volume are recommended for normal purposes. Other mixes may be used to meet particular purposes and advice should be sought from the supplier of the exfoliated vermiculite.

	Floor screeds 6:1 mix	**Roof screeds 8:1 mix**
Portland Cement	1 part	1 part
Exfoliated vermiculite concrete aggregate	6 parts	8 parts
Water	Approximately 1¼ parts†	Approximately 1½ parts†

† To test for a suitable consistency, a handful of the mix, when firmly gripped, should just release a little water, and no more. On no account should "sloppy" mixes be used.

e. Mixing and Laying

Small quantities of vermiculite concrete and screeds may be mixed by hand, but larger quantities must be mixed using mechanical mixers, such as paddle blade mixers. High speed vigorous mixing actions should be avoided, as these can break down the vermiculite aggregate and densify the mix. For hand mixing, combine the cement and vermiculite aggregate dry, and add the water from a watering can with a fine sprinkler nozzle and mix further. For machine mixing, combine the cement and water to form a thin grout, then quickly add all the vermiculite aggregate and mix only until an even consistency is achieved. Over mixing in both cases should be avoided as it creates undue compaction, increased density, and therefore poorer coverage and thermal performance. The mix then "balls-up" and becomes difficult to lay. The protective topping mix should be thoroughly mixed (preferably by machine) or by hand mixing if only small quantities are required.

f. Placing and Compaction

The vermiculite concrete or screed should be laid as soon as possible after mixing. Place the mix in position, overfilling by about 10% by volume to allow for compaction. Compact by lightly tamping and strike off level. If monolithic topping is to be applied, brush on a creamy grout of cement and water and immediately apply, compact and finish the topping screed. This application must be completed within about one hour to ensure the layers bond properly.

g. Curing and Protection

It is advisable to cover the finished screed with a polythene sheet for the first few days, then allow it to dry out naturally. Protect the screed from mechanical damage, rain leaks, etc., until the final flooring is laid. Repair any cracks or other damage prior to installation of the flooring or other covering.

h. Properties of Floor and Roof Screeds

Mix proportions	Floor screeds 6:1 mix	Roof screeds 8:1 mix
Air dry density [without topping] (kg/m^{-3})	450 - 480	320 - 410
Thermal conductivity ($Wm\text{-}1\ °C^{-1}$)	0.11	0.09
Compressive strength of screed (without topping) ($N\ mm^2$)	0.95	0.70
Concentrated Load to Cause Failure of $1mm^2$ of Compressed Screed (kg)	1.10	0.70
Recommended Maximum Concentrated Load per mm^2 (kg)	0.53	0.35
Fire Resistance	Incombustible	Incombustible

Insulating Concrete

In the construction industry, and in particular in North America, vermiculite concrete is used as an insulating concrete over galvanized centring or profile sheeting in roof constructions, as well as over pre-cast concrete decking and polystyrene vent-board.

The roofing construction using galvanized steel centring or profile sheet provides a maintenance free economical roof system. It consists of the high tensile galvanized profile sheeting fixed to the supporting structural steel framing using either specialist welded fixings or screws and bolts, together with either a 6:1 or a 8:1 vermiculite concrete mix. The thickness of the vermiculite concrete may be varied to provide necessary drainage slopes. The minimum thickness of the vermiculite concrete shall be 50mm (2 inches), over the top pane of the steel centring or profile sheet. A built-up roofing is then used to provide a weather proof finish over the vermiculite concrete.

The applications for vermiculite concrete over pre-cast concrete decks are to provide high insulation values and suitable drainage slopes to various types of pre-cast concrete units such as core type structural slabs, channel slabs, and pre-stressed single and double tees. Vermiculite concrete provides a smooth surface for applying the built-up roofing membrane. This application usually requires additional venting to be used. Roof vents are required at intervals of one per 95 m2 (1023 square feet).

When used over polystyrene vent-boards vermiculite concrete provides a system of superior insulation value comprising of a sandwich construction of the polystyrene boards and the vermiculite concrete applied over the structural base of regular concrete, metal sheeting or wood roof construction. This composite application gives a flexibility that meets most design criteria. The insulation values for this system can be varied by changing the thickness of the polystyrene board. Proper drainage slopes for this system can be formed using the vermiculite concrete and appropriate denser topping mixes and waterproofing systems on top of this. The minimum thickness of vermiculite concrete used in this application is 50mm (2 inches).

Vermiculite Concrete Blocks and Slabs

Blocks and slabs made with exfoliated vermiculite aggregate and Portland cement have found a variety of uses in the construction industry where a lightweight, fire-resistant and thermally insulating product is required. Typical uses are:

- Non-loadbearing partition walls
- Load-bearing walls with dense structural concrete cores
- Insulating slabs on structural roofs
- Permanent insulating shuttering to floors and roofs

a. Vermiculite Partition Blocks

The low density of vermiculite concrete blocks make them suitable for partitions where the dead load of the construction must be kept to a minimum. For example, the weight per square meter for a 75mm block wall can be as low as 30 kg (the weight per square foot of 3 inch thick block wall can be as low as 6 lbs). This type of block is suitable for applications such as conversion of old properties. Vermiculite concrete blocks are easily worked and may be sawn, nailed or drilled.

b. Mix Proportions

The standard mix for this application is a 5:1 mix by volume of coarse (2 – 6mm typically sized) vermiculite aggregate to Portland cement. However, this may be varied to suit the density and strength required and the method of manufacture.

c. Site Storage

These low-density blocks must be kept dry during delivery and storage on site. Blocks which have become wet must not be used until they have been effectively dried out.

d. Bedding Mortar

A low strength mortar should always be used.
The following mixes are likely to be suitable:

- 1:1:3:3 by volume Portland cement/lime/sand/ <2mm sized exfoliated vermiculite aggregate
- 1:2:9 Portland cement/lime/sand
- 1:8 Portland cement/sand plus plasticiser

e. Plastering

To improve the finish quality and the insulation value of the vermiculite concrete partition blocks, a propriety vermiculite gypsum plaster can be used. Alternatively, a sand/cement render such as the 1:2:9 Portland cement/lime/sand mix used as the bedding mortar above can be applied to the blocks.

f. Fixings

Where a particularly strong fixing is required, a special high-density vermiculite block should be inserted as work proceeds. Alternatively, loads should be well distributed.

g. Vermiculite Hollow Blocks with a Load-Bearing Concrete Core

A number of systems have been developed in the past which make used of a hollow vermiculite block with a dense concrete fill or core, poured during or soon after erection. The concrete core may be reinforced as required.

In this application, vermiculite blocks can be tongued and grooved on upper and lower faces to facilitate erection. The blocks are frequently laid “dry” without the use of mortar, saving time over conventional brick or block construction. The concrete fill is poured after every three of four courses of blocks have been laid, ensuring a continuous load-bearing core throughout the height of the wall.

Walls may be plastered and decorated as required. The external walls require the application of a propriety exterior rendering to provide a weather-proof and decorative finish. This system could also be used as an interior masonry construction with an outer brick or traditional concrete block facing with an appropriate cavity between the two walls.

h. Vermiculite Concrete Slabs for Roof Insulation

Vermiculite concrete slabs have been used for the insulation of flat and shell roofs in place of a vermiculite concrete screed installation. There are obvious advantages in site fixing of a factory made, all-dry insulation slab, which permits the immediate application of the weatherproofing surface layer without having to wait until the screed has dried out.

Slabs can be manufactured in a suitable block making machine and are usually 50mm (2 inches) to 75mm (3 inches) thick by 460mm (18 inches) by 230mm (9 inches) length to breadth. Mix proportions are of the order of 6:1 by volume of coarse (2-6mm typically sized) vermiculite aggregate to Portland cement, although this ratio may be varied to suit the strength and insulation value required.

It is normal practice to lay the cured and dried slabs directly to the structural concrete roof, although bedding in bitumen is sometimes specified. If necessary, the joints between the slabs may be pointed with a 4:1 by volume vermiculite/cement mix using one of the finer vermiculite grades (usually 1-3 mm typical size).

Where falls are required, a sand/cement screed in proportions varying between 4:1 and 6:1 is laid over the slabs and is followed by a waterproofing asphalt or roofing felt layer. Where falls are already incorporated in the roof slab, the vermiculite slabs should receive a thin sand/cement screed to a nominal 10mm (3/8th inch) thickness to ensure a fair surface to receive the waterproofing.

Manufacture of Vermiculite Concrete Blocks and Slabs

Many types of block-making plants are suitable for the manufacture of vermiculite concrete blocks and slabs as described above. When considering the choice of a plant, it should be remembered that vermiculite is an ultra-lightweight aggregate and, as such, is liable to compact if subject to undue compression or vibration. Systems involving only light vibrations and mechanical tamping are generally found to be the most satisfactory.

Materials

It is usually normal to use "extra-coarse" (3-15mm) or "coarse" (2-6mm) sized vermiculite aggregate for the manufacture of blocks and slabs, however, the finer vermiculite grades (usually 1-3 mm typical size) are preferable where a higher strength is required or the block design is very detailed. Portland cement should be used, with the addition of a plasticiser if desired. This may assist in the manufacture and slightly increase the yield, although it may be at the expense of strength.

Mix Proportions

Mix proportions vary between 4:1 and 8:1 vermiculite aggregate to cement by volume, depending on the use for which the product is intended and the method of manufacture.

The water content should be only sufficient to provide adequate plasticity in the mix. As a guide, the following quantities are likely to be required for the mixes shown. All proportions are by volume.

Vermiculite Aggregate	Portland Cement	Water
4	1	1
6	1	1¼
8	1	1½

Mixing

Care should be taken to avoid excessive mixing which will lead to an increased density in the finished product. Mixing machines having a beating action or a rapid cross mixing action will crush the vermiculite aggregate and should not be used. Paddle blade mixing with a rotation speed of less than 45 R.P.M. are preferred. Conventional drum concrete mixers are generally suitable.

Water should be poured into the mixer first, after which the cement should be added and mixed thoroughly to form a uniform slurry. The vermiculite is then added and mixed until a uniform distribution has been achieved, which normally takes place in 1½ to 2 minutes. Over-mixing should be avoided.

Drying and Curing

Vermiculite concrete blocks and slabs are normally stored under cover for at least four weeks to cure and dry. They must be thoroughly dry before dispatch to site. Storage on site should be under cover to ensure that the blocks and slabs are kept dry until used.

The Vermiculite Association

TVA is a domestic not for profit corporation incorporated in the state of Pennsylvania, USA.

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