Vermiculite roof deck and insulating concrete

Vermiculite, a mineral that has few uses in its crude state, becomes, when heated and exfoliated, an expanded light aggregate of great value in the production of lightweight fill and insulating concrete. Since the 1920's, the mining and processing of vermiculite has grown to a better than $30 million a year industry.

Compared with conventional aggregates, the price of vermiculite aggregates is relatively high; but the use of vermiculite concrete can result in significant savings in weight of steel. It is also more fire resistant and has heat and sound insulating properties considerably superior to those of conventional concrete. Vermiculite's thermal conductivity (K factor), ranges from 0.6 to 0.97 BTU per hour per square foot (degrees F. per inch), depending mainly on the mix ratio . The lighter the concrete, the better (lower) the K factor.

Vermiculite has been found in twelve states and is mined commercially in seven. A soft, laminated, mica-like material in its raw form, vermiculite is graded at the mine according to the finished products desired. The crude vermiculite is crushed, cleaned, dried and sized, and the resulting concentrate is shipped to processing centers, where it is exfoliated in furnaces at temperatures of 1800 to 2000 degrees F.

Since vermiculite is low in weight but high in bulk, long distance shipment is uneconomical. Consequently, expanding plants have been established at market centers to process the screened and cleaned material from the mine.

The most common use of vermiculite lightweight concrete is for light, structural roof decks, and for insulation fill over metal decking and structural concrete. Vermiculite for roof decks can be placed over various kinds of form boards—fiber, glass fiber, acoustical, and cement-asbestos—as well as over paper backed wire lath. Vermiculite concrete is highly adaptable for concrete roof systems. Almost any architectural requirement can be met by changing the type of form, slab thickness, concrete mix, or support spacing. Drainage slopes can be incorporated into one monolithic surface and the concrete can be placed on steep inclines.

The recommended mixture of vermiculite concrete for roof deck construction is 1:4. Vermiculite is usually sacked in units of 4 cubic feet each. A 1:4 mix will give a density of 35 to 40 pounds per cubic foot, and compressive strength of 350 to 500 psi. The indentation resistance will be 410 to 515 psi, and the rupture modulus, 180 to 205 psi.

Vermiculite, like other insulation materials, works in two ways: it keeps heat within a building in winter and it keeps heat out in summer. Material that insulates well results in greater comfort for those who use the building, lower initial costs in air conditioning and heating equipment, and lower operating costs for that equipment.

For concrete roof insulation, vermiculite mixes of 1:6 and 1:8 can be used. When the necessary roof live load is less than 30 pounds per square foot, and the temperature is above 40 degrees F., the 1: 8 mix is recommended. The properties of each mix are shown in the table below:

	1 :6	1 :8
Density	25- 30 lbs./cu.ft.	20- 25 lbs./cu.ft.
Compressive strength	125-225 psi	100-125 psi
Indentation resistance	165-270 psi	100-145 psi
Rupture modulus	120-135 psi	45-90 psi

The heat-resistant qualities of vermiculite lightweight concrete also provide considerable fire protection. Factors affecting fire resistance are the resistance of concrete to the flow of heat, its thermal expansion, and its chemical and mechanical stability. Concrete's fire-protective function ranges from that of supporting loads during and after a fire, to that of serving as expendable, insulative protection for structural steel from high temperatures during a fire. Vermiculite is an incombustible insulation, and in addition it serves as a buffer between combustible roofing materials and materials used in the interior of a building. Fire resistance ratings up to 4 hours are attainable for various vermiculite roof assemblies. Good ratings are also possible for vermiculite-coated, loadbearing walls. Here, however, the required thickness depends on the nature and the amount of reinforcement and on the utilization of mixes possessing greater density and structural value than ordinarily required in roof-fill applications.

Needless to say, vermiculite concrete's fire rating means low insurance rates on buildings and contents, as well as maximum coverage on sprinkler heads if required.

Vermiculite concrete can be mixed in a horizontal-drum rotating-paddle type mixer. The water and cement are placed in the mixer, and then the aggregate. Mixing

Pumping a 1:6 mix of vermiculite insulating concrete 4 inches thick on the gable roof of a supermarket. Almost any architectural requirement can be met by changing the type of form, slab thickness, concrete mix or support spacing, and steep inclines can be dealt with readily.

is limited to the minimum time required to obtain a thorough mix and proper fluidity. The maximum time recommended is five minutes. When transit mixed vermiculite concrete is used, the water and cement are placed in the mixer, which is rotated slowly until all the aggregate has been added. The drum continues to rotate for about one minute after the aggregate is in the mixer, but is not rotated on the way to the job site. At the job the concrete is mixed at the fastest speed until it is uniform and flows freely from the mixer.

In a rotating-paddle mixer, an increase of the speed of rotation will provide air entrainment and will reduce the quantity of air-entraining agent required. The total percentage of air entrained will depend on the size of mixer and the duration of mixing; the proper quantity of air entraining agent may have to be determined by trial and error for the particular mixer and the desired density.

Placement and screeding of vermiculite concrete should proceed immediately after mixing. The time between the final mixing and the placement should be sufficiently brief so as to allow no appreciable change in the consistency of the mix. Two inches is the recommended minimum thickness of vermiculite over form boards. Over cement-asbestos, 2¼ inches should be placed.

The procedure for curing vermiculite lightweight concrete is essentially the same as for curing conventional concrete. Vermiculite concrete should be substantially dry before the application of the roofing.

Concrete used for roof decking should have the following characteristics before it is ready for built-up roofing: (1) sufficient hardness to withstand foot traffic and normal roofing operations; (2) surface should be firmly bound and be free from loose material and extreme roughness; and (3) exposed surface should be a gray cement color and look and feel dry. In this state, the hot, mopped bond coat can be applied smoothly and it will adhere well to the surface.

As with expanded slag, clay, shale, and slate aggregates, the tendency of vermiculite aggregates to absorb water makes it difficult, if not impossible, to determine an accurate value for the net water/cement ratio.

Water requirements per cubic yard of vermiculite concrete do not vary greatly with proportions. In tests using proportions of 1: 3 to 1: 16, the range of water requirements was about 75 to 105 gallons per cubic yard of concrete. The mixes ranged from 1/8-inch to about 9-inch slump.

In summary, vermiculite lightweight concrete can result in overall savings despite the relatively high cost of the aggregate. Its lightness makes possible a reduction in the weight of steel, its insulating qualities reduce the initial and operating costs of air conditioning and heating equipment, and its fire-resistant properties result in greater fire protection and lower insurance rates.

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