PERLITE INSULATING CONCRETE

APPLICATION AND DESIGN INFORMATION FOR CONTRACTORS

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CHAPTER I — GENERAL

1.1—Scope

This document brings together pertinent information on the design and placement of perlite insulating concrete. The use of this information is for roof deck applicators responsible for the installation and application of perlite insulating concrete.

1.2—Definition

Perlite insulating concrete is a combination of perlite aggregate, portland cement, air entraining agent, water and/or other additives producing a concrete with an oven dry density of 50 lb/ft^3 (800 kg/m^3) or less.

1.3—Usage

Field placed perlite insulating concrete is commonly used for insulating roof decks, fills and other semi-structural insulation applications.

Perlite insulating concrete roof decks may also employ expanded polystyrene insulation board which is embedded in the concrete.

1.4—Applicable ASTM Standards

- C 150: Specifications for Portland Cement
- C 332: Specifications for Lightweight Aggregates for Insulating Concrete
- C 495: Method of Test for Compressive Strength of Lightweight Insulating Concrete
- C 513: Method of Securing, Preparing and Testing Specimens from Hardened Lightweight Insulating Concrete

CHAPTER II — MATERIALS

2.1—Perlite Aggregate

Perlite aggregate conforming to ASTM Designation C 332, Group I.

2.2—Cement

Portland cement conforming to ASTM Designation C 150, either Type I, Type II or Type III.

2.3—Air Entraining Agent or Other Additives

It is recommended that the perlite aggregate manufacturer be consulted for information and data.

2.4—Water

Water should be clean and free of deleterious substances.

2.5—Control Joints

Shall be a highly compressible vapor permeable material which will compress to one half its thickness under a load of 25 lb/in^2 or less (172 kPa).

2.6—Embedded Insulation

Shall be expanded polystyrene insulation board with a minimum density of 1 lb/ft^3 (16 kg/m^3).

2.7—Reinforcing Mesh

Shall be a galvanized wire mesh with a minimum cross sectional area of .026 in^2 (.169 cm^2).

2.7a—Reinforcing Fibers for Reroofing

Shall be alkali-resistant glass or polypropylene, ¼ to ½ inch in length, 15 denier.

CHAPTER III — CONCRETE PROPERTIES

3.1—Compressive Strength

Should be determined in accordance with ASTM Designation C 495.

3.2—Mechanical Fasteners

Perlite insulating concrete has a nailability capacity suitable for the mechanical attachment of the base ply of built-up roofing [40 lbs. (18.2 kg.) minimum nail pull]. ES Nail-Tite MK III (Zono-Tite) nails, Simplex Tube Lok nails, E. G. Insuldeck Loc-nails, or Berryfast Tape/Staple systems are suitable fasteners for this purpose.

3.3—Oven Dry Unit Weight

Oven dry weight is a measure of the insulation value of the perlite concrete and may be determined in accordance with ASTM Designation C 495.

TABLE 3.1a TYPICAL PHYSICAL PROPERTIES OF PERLITE CONCRETE

Typical Oven Dry Density lb/ft³	Dry Density Range lb/ft³	Thermal Conductivity Range Btu-in./hr-°F-ft² "k"▲	Compressive Strength Range lb/in²	Minimum Compressive Strength lb/in²	Wet Density Range lb/ft³
36	36–42	.83–.97	300–500	300	48–56
30.5	30–36	.71–.83	200–300	200	42–50
27	24–30	.58–.71	125–200	125	38–44
22	18–24	.46–.58	80–125	80	34–40

▲1985 ASHRAE Handbook of Fundamentals

Note: Expanded polystyrene board of 1 lb/ft³ (16 kg/m³) density has a "k" factor of .24 at 40°F (1.36 W/m K at 4.4°C).

TABLE 3.1b TYPICAL PHYSICAL PROPERTIES OF PERLITE CONCRETE IN METRIC UNITS

Typical Oven Dry Density kg/m³	Dry Density Range kg/m³	Thermal Conductivity Range W/m. K	Compressive Strength Range kPa	Minimum Compressive Strength kPa	Wet Density Range kg/m³
576	576–672	.12–.14	2068–3447	2068	768–896
488	480–576	.10–.12	1379–2068	1379	672–800
432	384–480	.08–.10	862–1379	862	608–704
352	288–384	.07–.08	552– 862	552	544–640

CHAPTER IV — DESIGN CONSIDERATIONS

4.1—Control Joints

It is recommended that at least a 1 in. (25mm) control joint be provided through the thickness of the perlite concrete at the junction of all roof projections and parapet walls.* This should be incresed to 1-1/2 in. (37.5mm) for roof areas over 100 ft. (30m) in length.

This recommendation assumes that suitable consideration has been given to the use of adequate through - building control joints.

**This recommendation does not apply when the roof deck is designed as a diaphragm to resist horizontal forces and galvanized corrugated metal form units are employed.*

CHAPTER V — PROPORTIONING AND MIX DESIGN

5.1—Materials per Cubic Yard

Refer to Table 5.1 below:

TABLE 5.1a MATERIALS PER CUBIC YARD BASED ON 100% YIELD

Mix Ratio (Cement/ Perlite Aggregate) Volume	Oven Dry Density (Typical) lb/ft³	Cement bags	Perlite ft³	Water gallons	Air Entraining Agent pints	Wet Density Range lb/ft³
1:4	36	6.75	27	61	*	48–56
1:5	30.5	5.40	27	59.5	*	42–50
1:6	27	4.50	27	54	*	38–44
1:8	22	3.38	27	54	*	34–40

* Air entraining agent. Neutralized vinsol resin or other air entrainment agent. Follow manufacturers recommendations.

TABLE 5.1b MATERIALS PER CUBIC METER BASED ON 100% YIELD

Mix Ratio (Cement/ Perlite Aggregate) Volume	Oven Dry Density (Typical) kg/m^3	Cement kg/m^3	Perlite m^3	Water m^3	Air Entraining Agent m^3	Wet Density Range kg/m^3
1:4	576	376	1.0	.30	.0041	768–896
1:5	488	301	1.0	.29	.0041	672–800
1:6	432	252	1.0	.27	.0041	608–704
1:8	352	188	1.0	.27	.0041	544–640

5.2—Air Entraining Agent

The use of the correct amount of air entraining agent is very important in successful perlite concrete construction. The air entraining agent produces countless tiny air bubbles in the concrete which reduces the density, increases the yield and contributes to the insulation factor of the dry concrete.

5.3—Job Mixing

Perlite insulating concrete should be mixed in a mechanical mixer designed expressly for lightweight insulating concrete. The required amount of water as specified or predetermined for the batch is placed in the mixer, followed by the air entraining solution, cement and perlite aggregate. The batch is then mixed until workable (approximately 1-1/2 to 3 minutes). Check wet density for conformance to specification range, discharge and place immediately. Mixing time is governed by the type of equipment used and can be determined by checking the wet density of the perlite concrete at intervals until the specified wet density is reached.

5.4—Yield Calculation

Yield is defined as the ratio between the volume of the wet perlite concrete as discharged from the mixer and the volume of perlite concrete aggregate used in the mix. The mix proportions included in Tables 5.1a and 5.1b are based on extensive field and laboratory tests and are established for 100% yield. If the correct quantities of materials and mixing procedure are used, a 100% yield should result. 100% of yield is of importance from the standpoint of economy and physical properties of the dry concrete.

5.4.1—Yield Check for Wet Density

The first step necessary in making a field check for yield is to determine the wet density of the perlite insulating concrete. Wet density can be checked beginning with the first batch mixed. Adjustments to the mixing procedure should be made at that time and additional checks made from time to time during pouring.

A simple method of field checking wet density is as follows:

1. Determine the exact volume of a cylindrical container such as a 10 quart galvanized bucket. This can be done by first weighing the bucket empty, then filling it level full with water and weighing it again and subtracting the bucket weight. This gives the net weight of the volume of water, and if divided by the density of the water, the result is the exact volume of the container.

EXAMPLE:

Weight of empty bucket: 2 pounds 0 ounces

Weight of bucket filled with water: 23 pounds 0 ounces

Net weight of water: 21 pounds 0 ounces

$$\text{Volume} = \frac{\text{Net weight of water}}{\text{Density of water}} = \frac{21}{62.4}$$

$$= 0.336\ ft^3$$

EXAMPLE: USING METRIC UNITS

Weight of empty bucket:	.9 kg
Weight of bucket filled with water:	10.5 kg
Net weight of water:	9.6 kg

$$\text{Volume} = \frac{\text{Net Weight of water}}{\text{Density of water}} = \frac{9.6\ kg}{999\ kg/m^3}$$

$$= .01\ m^3$$

2. Fill the container with the wet perlite concrete and weigh again. Subtract the weight of the empty bucket and divide the remainder by the volume as determined in Step 1 above. The result is the wet density of the perlite concrete in pounds per cubic foot.

EXAMPLE:

(A mix with typical wet density of 40.5 lb/ft^3)

Weight of bucket and perlite concrete: 15 pounds 8 ounces

Weight of empty bucket: 2 pounds 0 ounces

Weight of perlite concrete: 13 pounds 8 ounces

$$\text{Wet density} = \frac{\text{Weight of perlite concrete}}{\text{Volume}} = \frac{13.5}{0.336}$$

$$= 40.2\ lb/ft^3$$

EXAMPLE: USING METRIC UNITS

(A mix with typical wet density of 40.5 lb/ft^3 = 648 kg/m^3)

Weight of bucket and perlite concrete: 15 lbs 8 oz = 7.38 kg

Weight of empty bucket: .90 kg

Weight of perlite concrete: 6.38 kg

$$\text{Wet density} = \frac{\text{Weight of perlite concrete}}{\text{Volume}} = \frac{6.38}{.01}$$

$$= 638 \text{ kg/m}^3$$

5.4.2—Field Check for Yield

The wet density and the weight of total ingredients for the mix being used are then substituted in the following formula:

$$\text{(a)} \quad \frac{\text{Weight of total ingredients}}{\text{Wet Weight per cu. ft. of concrete}} = \text{Yield}$$

$$\text{(b)} \quad \frac{\text{Yield}}{\text{Total cu. ft. of perlite aggregate}} \text{X } 100$$

$$= \%\text{Yield}$$

EXAMPLE:

Consider a mix of 1 bag cement (94 lbs.) to 6 cubic feet of perlite concrete aggregate.

The wet density as determined in the Example is 40.2 lb/ft^3.

The weight of total ingredients is as follows:

Portland cement: 1 bag	94.0 lbs.
Perlite aggregate: 6 cu. ft. @ 8.0 lbs./cu. ft.	48.0
Water: 12 gallons @ 8.33 lbs./gal.	99.96
Air entraining agent: 1-½ pints @ 1 lb./pint	1.50
Total	243.46 lbs.

$$\text{Substituting in formula (a): } \frac{243.46}{40.2} = 6.05 = \text{Yield}$$

$$\text{Substituting this value in formula (b): } \frac{6.05}{6} \text{X } 100 = 101\%$$

EXAMPLE: USING METRIC UNITS

Consider a mix of 1 bag cement (42.73 kg) to 6 ft^3 of perlite concrete aggregate (.17m^3).

The wet density as determined in the Example is 638 kg/m^3. The weight of total ingredients is as follows:

Portland cement:	42.73 kg
Perlite aggregate: (.17 m^3 @ 128 kg/m^3)	21.78 kg
Water: 45.42 liters	45.44 kg
Air entraining agent: 708 ml	.68 kg
Total	110.63 kg

$$\text{Substituting in formula (a): } \frac{110.63}{638} = .173 = \text{Yield}$$

$$\text{Substituting this value in formula (b): } \frac{.173}{.17} \times 100 = 101\%$$

5.4.3—Loss of Yield

If the yield as checked by the wet density method is LESS than 100%, a "loss of yield" is evident. A loss of yield may be attributed to one or more of the following factors which should be checked:

1. Air Entraining Agent: Be sure that the proper type and amount of air entraining solution is being added to each mix.

2. Mixing Procedure and Time: Be sure that the materials are added to the mixer in the proper order. Undermixing of the perlite concrete will usually result in a loss of yield. Overmixing can adversely affect air entrainment.

3. Water: Check the quantity of water added to the mix. After about one minute of mixing, properly proportioned perlite concrete often looks too dry and field personnel add water for plasticity. Extra water sometimes reduces yield. Usually hard water offsets the effects of the air entraining agent, and the perlite manufacturer should be consulted for additional air entraining recommendations.

4. Types of Bases: In some cases even though the yield of the perlite concrete is correct as discharged from the mixer, more materials are required for the job than estimated. When estimating the cubic yards of perlite concrete required, consideration must be given to the type of base used. Some bases sag slightly between supports and additional concrete is required to give a level top surface; others allow small quantities of the concrete to drop through and be wasted. Depending on the type of base used, an average concrete thickness should be used for estimating and a small addition made for waste.

CHAPTER VI - INSTALLATION

6.1—Placement

Perlite concrete should be conveyed from the mixer to the place of final deposit by methods which will prevent segregation or loss of material. Equipment for conveying perlite concrete should be designed to insure delivery without separation of materials or serious loss of air content.

Pumping should be in accordance with recommendations of the perlite producer, and the perlite concrete shall meet the specified properties at the point of placement.

Perlite concrete should be deposited and screeded in a continuous operation until the placing of a panel or section is completed.

Expanded polystyrene board should be placed in a minimum 1/8 in. (3.1 mm) wet slurry of insulating concrete. It is recommended the board be covered by perlite concrete to finished thickness before the slurry is set.

6.2—Curing

Normal Conditions: Perlite concrete has an adequate mixing water content so as to have sufficient water for proper curing of the concrete without additional precautions. Under these conditions the concrete should be permitted to air dry.

Extreme Dry Conditions: When perlite concrete is placed during extreme dry weather, additional water may have to be sprinkled on the concrete for a sufficient period of time to allow hydration of the concrete.

Cold Weather Conditions: For winter pouring the use of high early strength (Type III) portland cement is recommended. All concrete materials, reinforcement and forms with which the perlite concrete may come in contact should be free of frost. No frozen material or materials containing ice should be used. When it is anticipated outside temperature will be below 40°F (4.4°C) 24 hours after placing of the concrete, the mixing water should be heated to a maximum of 120°F (48.9°C). Perlite insulating concrete should not be placed during freezing weather unless the contractor is experienced in the special techniques required.

6.3—Roofing Recommendations Over Perlite Concrete

The built-up roofing or single-ply membrane should be applied as soon as the perlite insulating concrete can carry construction traffic, and is dry enough to develop adhesion with hot asphalt or pitch.

Roof application should proceed when the perlite concrete has been cured a minimum of three days. Provision shall be made for perimeter or edge venting by use of an open metal gravel guard or facia.

6.3.1—Mechanical Fasteners

Nailing or stapling are preferred methods of attachment for the base sheet, and shall be used on perlite concrete applied over structural concrete.

CHAPTER VII - RECOMMENDED PRACTICES FOR WORKMANSHIP AND TOLERANCES

7.1—Variation of Plane

Variation in deck thickness should be no greater than ± 1/4 in. (6.25 mm) on a 10 ft. (3 m) straight edge. This tolerance does not include variations resulting from substrate.

7.2—Variation In Deck Thickness

Variation in deck thickness should be no greater than ± 1/4 in. (6.25 mm) from specified thickness established by averaging measurements taken at 3 points on a 10 ft. × 10 ft. (3 m × 3 m) square.

7.3—Rain or Freezing Damage Before Setting of Concrete

It is recommended the deck be allowed to cure for a minimum of three days. After freezing or heavy rainfall give a thorough brooming if required before roofing.

That portion of the deck which has excessive scaling should be removed to solid concrete, and patched. Patch additives may be used at the applicator's option.

If minor scaling occurs broom surface before roofing.

Perlite concrete exposed to extreme cold after setting will provide adequate strength to receive roofing if not subjected to mechanical damage. Therefore, all traffic should be prohibited.

Damage after placement caused by other trades should not be the responsibility of the applicator.

CHAPTER VIII - ALTERNATIVE DESIGN

8.1—Reroofing

Perlite reroof base is the ideal underlayment for use in renovating existing roofs. It is unsurpassed in correcting irregularities in uneven existing roofs of virtually any material. It provides high insulation values as well as the additional benefits of eliminating ponding, slope-to-drain, lightweight and can often eliminate costly tear-offs of old roofing.

Perlite reroof base is a strong, fiber reinforced nailable base which improves the fire resistance of the roof system. It is used to separate an old roof from a new reroof system while providing a smooth monolithic surface for new built-up roofing or single-ply membranes.