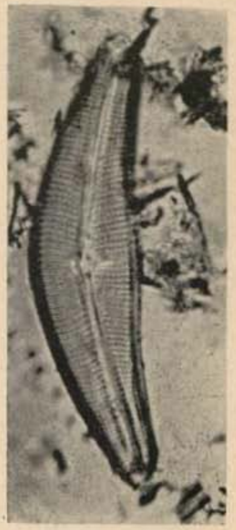
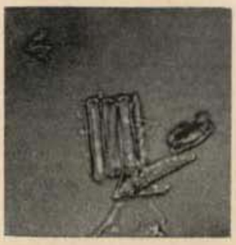
Woodfibre Diatomite Concrete

LIGHTWEIGHT BUILDING MATERIAL

by
WALTER R. FRIBERG





UNIVERSITY OF IDAHO
COLLEGE OF AGRICULTURE
D. R. THEOPHILUS
Director

These men found it easy to pour a flat roof-slab with the wood-fibre-diatomite aggregate. A worker can handle more than twice as much of the light material as he can of regular concrete.

ON THE COVER

Our cover picture shows highly magnified photographs of individual diatoms that make up much of the concrete we discuss in this bulletin.

The size of the average diatom is less than one two-hundredth of an inch in size. Diatoms live in practically all bodies of water having normal conditions and temperatures. Really a plant with some of the characteristics of the animal world, diatoms reproduce rapidly by cell division. A single parent can have more than a billion progeny in one month's time.

Because of this rapid reproduction, there was—millions of years ago just as today—a constant "rain" of these microscopic plants on the bottoms of some of our lakes and oceans. This "rain" of diatoms built up thick layers of what we call diatomite. As the earth's surface changed, the waters receded and left the diatomite deposits where we find them today. The greatest of these are in the western part of the United States.

Scientists have identified some 15,000 types of diatoms. Most of these types vary but slightly from each other. We find that the diatoms of today differ but little in skeleton from their ancestors of millions of years ago although the generations in between run into more figures than we can comprehend.

The uses of diatomite are many. Certain types of high purity are very useful in filters, scouring powders, polishes, insulation, and even in paints and wood preservatives. For our concrete, we need no special type of diatom. Even the impurities such as clay, volcanic ash, and lime that are so frequently mixed with diatomite do not form a disadvantage for our use.

The pictures are by Harold Powers, School of Mines, 1947.

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LIGHTWEIGHT AND INSULATIVE CONCRETE

For many years home builders have needed a building material that combines good insulation with enough strength to stand up well under ordinary structural weights and loads. Such a material is a part of our common desire for better homes and greater security. With the coming of national advertising concerning the values of better home insulating, the demand for more efficient building material became greater. The need for such material is definite. Home heating costs have increased greatly over the last few years; most fuels have doubled in price. As a result we are no longer willing to let expensive heat escape from our dwellings because of poor insulation.

Because of this growing demand, the Agricultural Experiment Station of the University of Idaho some years ago undertook the task of finding such a building material. In our search, we stayed within the limits of materials that were inexpensive and easily available. We wanted materials which we could work with ordinary farm equipment, and, as nearly as possible, we wished to use raw materials which we could find within Idaho's boundaries.

There are many excellent insulating materials on Idaho markets, but nearly all are imported into the state. Because of this, the price increases with freight and handling charges. By the time these materials get to you as the ultimate consumer, the price is high when compared to what a good Idaho product would cost.

After many experiments we found that we could make a material having both strength and insulating qualities. The formula called for wood-wastes such as sawdust and shavings mixed with clay, Portland cement, and a raw material known as diatomite. Sawdust concrete itself is not a new idea. Many people have experimented with the mixture but have made little practical use of their findings. Such concrete required a large proportion of cement to obtain the required strength; this meant increased cost and weight and gave decreased insulative qualities. These faults defeated the purpose of the sawdust concrete.

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Ingredients: Diatomite, sawdust, shavings. Note size of mixer. Light weight allows mixing large batches of this concrete.

By mixing certain amounts of diatomaceous earth in the sawdust concrete, we found that we could decrease the amount of cement and produce a lighter and more insulative material. Additions of clay increased the strength, hardness, and water tightness of the mixture.

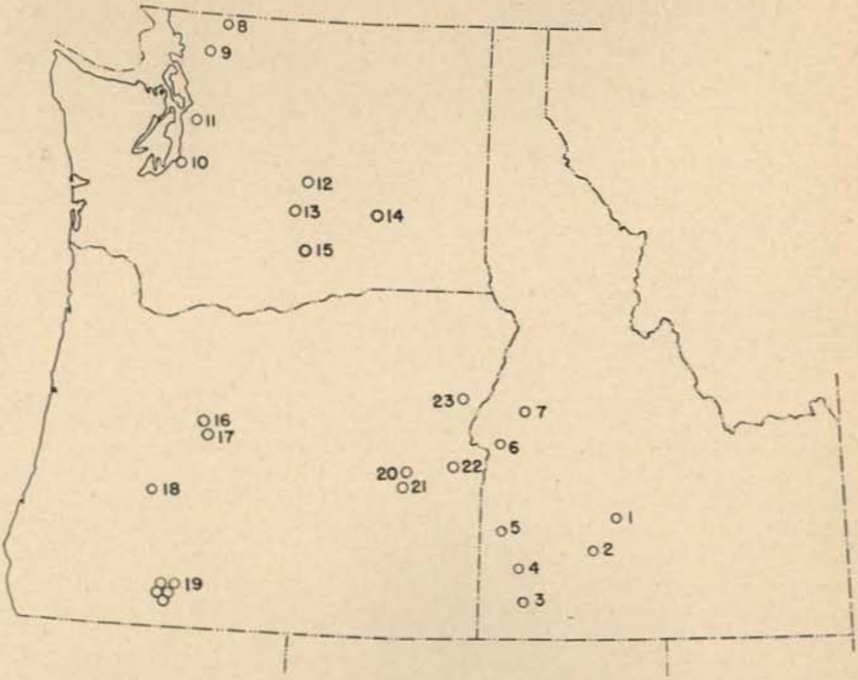
Before we go on with our discussion of this concrete, let's take a close look at diatomite. Not many of us are familiar with diatoms or diatomaceous earth under that name, although we have used it in scouring powders and other forms for many years. The origin of our diatomite deposits is as interesting as the history of the earth itself. We know that these microscopic plants lived and died in the sea millions of years ago leaving their tiny skeletons to build up the deposits we find on dry land today. Under the microscope, this almost pure white powder shows such skeletons as we have pictured on the cover of this bulletin. Those are four main forms that the diatoms left us in their skeletal remains—all of different shape yet all belonging to the same general family. Idaho has many known diatom deposits, and there are probably many that we have not located.

Pure diatomite is white and soft, and closely resembles chalk in appearance. Clay and other impurities frequently change its color to yellow, brown, or almost black. These impurities also make it harder and heavier. For use in sawdust concrete, the diatomite may contain a high percentage of impurities without lowering the quality of the concrete. It is usually mined by open-pit methods, with a bulldozer, plow, or ripper. The supply of diatomite far exceeds the demand, so the price should be, and usually is, quite low.

At the pit, diatomite is a mixture of powder and lumps. The lumps must be pulverized before use, and a hammermill does this best. When milled dry it dusts badly, so we usually dampen it, then allow it to stand in the pile a few days before grinding.

The map shows the location of reported diatomite deposits in

Location of Explored Diatomite Deposits in the Pacific Northwest



1. 8.2 miles north of Fairfield, SE¼ Sec. 33, T2N, R14E.
2. From road cut 2 miles up Bellmare Creek, or 4 miles NE of King Hill, SW¼ Sec. 27.
3. Owyhee County Secs. 34, 35, and 36, T11S, R2W.
4. Owyhee County, east of Silver City.
5. About 25 miles south of Nampa.
6. A few miles east of Weiser.
7. Near Indian Valley, on the Little Weiser River.
8. Along the highway 2 miles west of Baker Lake in Sec. 30, T38N, R8E.
9. ¾ mile SE of Big Lake postoffice, on Nookachcamp Creek, Sec. 25, T34N, R4E.
10. 2 miles west of Parkland, Sec. 8, T19N, R3E, covered with water in winter.
11. 2½ miles north of Maxwelton on Useless Bay.
12. Several deposits 13 to 16 miles SW of Quincy in T18N, R23E. Reached by county roads branching from Ellensburg. Ritzville Highway.
13. A number of deposits in Kittitas County in the Squaw Creek area about 17 miles SE of Ellensburg, T15N, R19-23E.
14. Adams County, Sec. 25, T16N, R30E, about 12 miles east of Othello.
15. Yakima County Sec. 2, T10N, R22E, about 5 miles NW of Sunnyside.
16. In river gorge NW¼ Sec. 25, T11S, R11E on Warm Springs Indian Reservation.
17. NE¼, Sec. 16, T14S, R12E, 17 miles NW of Bend.
18. 11, T23S, R7E on Odell Creek ⅓ mile east of Davis Lake Ranger Station.
19. Several large deposits north of Klamath Falls, Sec. 35, T34S, R7E, T38S, R9E; Sec. 18, T39S, R9E; Sec. 14, T39N, R10E; Sec. 27, T38S, R11½E.
20. NE¼ Sec. 17, T20S, R36E, 6 miles NE of Drewsey.
21. On Burns-Ontario Highway 12.4 miles west of Juntura SW¼ Sec. 36, T20S, R36E.
22. Large beds in north-central Malheur County. 2 to 12 miles NE of Harper.
23. Center of Sec. 28, T11S, R43E, 2 miles south of Durkee.

Laying precast blocks of S D concrete. Blocks were laid as back-up for the brick veneer. Corrugated metal ties hold the back-up block to the brick.

the Northwest. There are many more. We have not surveyed or examined many in the Snake river valley from Payette to St. Anthony, but we know they are there. If you are interested in the location of deposits in other states, write to the Department of Geology at your State College or University. An excellent bulletin describing diatomite is available from the University of Idaho Research Council. Ask for Idaho Mineral Resources Report No. 4 "Diatomite Deposits of Southwestern Idaho." There is no charge for this bulletin.

Diatomaceous earth is not the only important ingredient in our concrete. Here are some of the other materials we must have. Remember that getting the right ingredients and handling them properly will go far in making sure that the finished building will be the most satisfactory.

SAWDUST: In our experiments we used a mixture of red and white fir, larch, and yellow pine sawdust. Any of these, or a mixture of them is suitable. Research work on cement-sawdust concrete at the University of Minnesota and Oregon State College indicates that sawdust from cedar, cottonwood, Douglas fir, oak or maple is inferior and should not be used. Although we did not test these woods with the diatomite-clay mixtures, there is no reason to believe the mixture would strengthen these inferior woods sufficiently to make them usable.

Use sawdust that has been exposed to the weather for at least 6 months but has not lain outside so long that it has become gray in color or has begun to rot. Screen it through a ½" or 1" mesh sieve to remove the chunks of bark and wood.

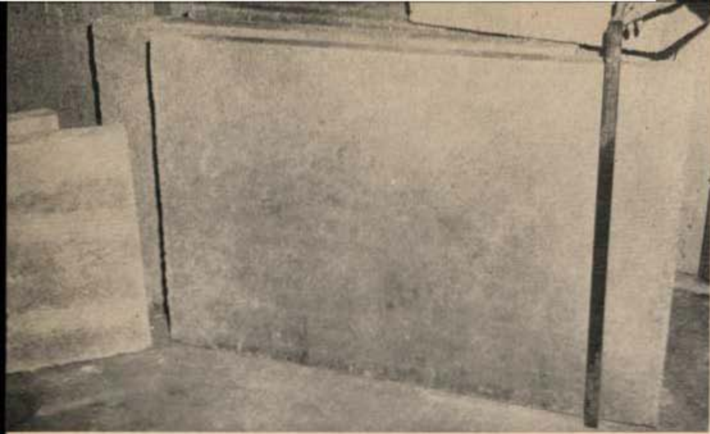
You can replace part of the sawdust with planer shavings. Shavings fresh from the planer mill may be used. They do not require weathering as sawdust does. The amount of shavings permissible depends on the size of the chips. You can use coarse planer shavings up to half-and-half with sawdust. You may increase the percentage of shavings if you use fine ones. Air spaces between the shaving chips in wet concrete show that the mix contains too much shavings. This is the signal to use less shavings and more sawdust until the air spaces are filled.

CLAY: You can use almost any kind of clay, but it must not contain much silt or organic matter. Add the clay either as a thin mud or a dry powder. If you use it as a mud, soak it in water for at least a day before use and stir it sufficiently to break up the lumps. Powdered or pulverized clay is easier to mix. A hammermill can pulverize the clay best. Dampen the clay very slightly before milling it. If the clay is too wet, it will plug the mill; if too dry, it grinds more slowly and with more dust. We found the best method was to mix the clay and diatomite together and then grind the mixture. To do this is simple. Make a pile of alternate layers of clay and diatomite, no layer more than 2" thick. Sprinkle water on each layer of clay until it has soaked up all the water it will hold. This is for dry diatomite. If the diatomite is damp, use less water on the clay. Let the pile stand for a few days, or until the clay and diatomite are of equal dampness. Shovel the mixture into the hammermill from the edge of the pile, so that each shovelful has the proper proportions of clay and diatomite.

MIXING

Unless you need only a small quantity of concrete, use a power concrete mixer if you can possibly find one. Diatomite mortar is fibrous and makes hand mixing hard work. Any concrete mixer is suitable. This mixture will require less power than does sand and gravel concrete. Mix at least three minutes, preferably four,

Parts By Volume				Compressive Strength Per Square Inch		Per Cent Absorption	Weight Pounds Per Cubic Foot
Cement	Sawdust	Diatomite	Clay	7 Day	28 Day		
1	3	0	0	45	146	62	46
1	4	0	0	25	74	86	35
1	5	0	0	22	60	99	34
1	6	0	0	19	55	110	31
1	3	1	0	377	652	46	57
1	4	1	0	276	444	66	42
1	5	1	0	180	317	69	44
1	6	1	0	108	198	78	41
1	7	1	0	64	119	120	33
1	5	0	1	233	395	54	50
1	5	1	1	388	554	43	58
1	6	1	1	212	400	73	49



Precast slabs to be used for roof or floor construction. Welded wire mesh should be used in the lower face when the slabs are supported on joist or rafters.

after all your ingredients are in the mixer. Put the sawdust and water into the mixer first, then the clay and diatomite, the cement last.

Do not use more water than is necessary for a workable mix —one that requires a little tamping for placement in forms. Under no circumstance add so much water that the concrete will flow. If you make building blocks of this concrete, have the mix dry enough so that you can immediately remove the forms or mold, but use as much water as possible without causing the block to lose shape. Be sure the mixture will just stand up without slumping out of shape when you remove the mold.

PLACING AND CURING

Place this concrete in forms and cure it in the same way you would handle sand-gravel concrete. As it is lighter, you can place it faster and more easily. The more you tamp it, the stronger it will be. As it contains more water than sand-gravel concrete, it does not require so much care during the curing period, but you must protect it from sun and drying winds.

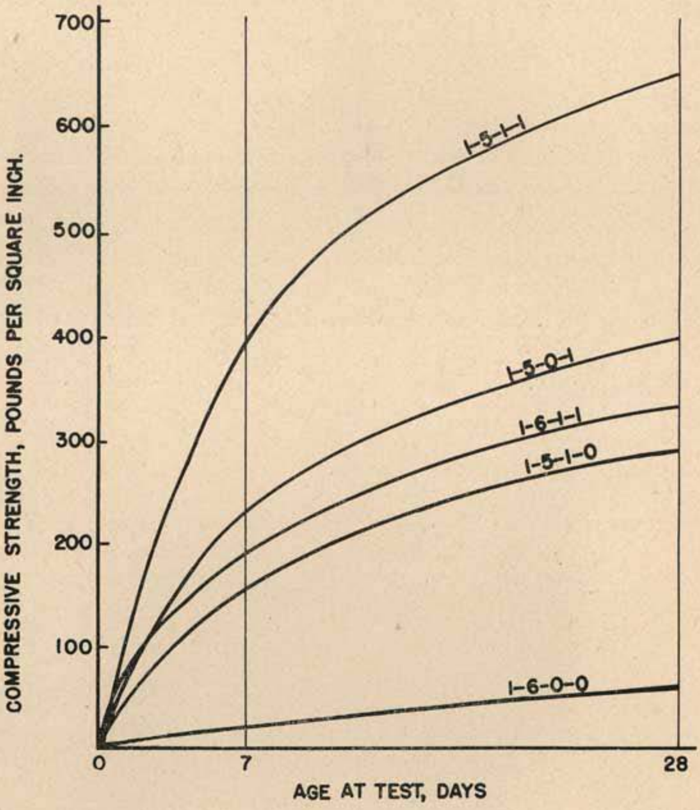
We have poured floor and roof slabs of this material with good results and with much less work than sand-gravel concrete required. We used a thickness of 3½″ to 4″. So far, we have not developed a floor surface with sufficient resistance to wear. Unless the traffic on the floor is very light, add a thin topping of sand concrete. If you do this, leave the surface of the wood concrete rough so the topping will stick better. For roof slabs and for floors which are to stand only light traffic, first screed the wood concrete level. Then immediately sprinkle it with a 50-50 mixture of dry sand and cement and work this slightly into the surface with the screed, rod, or float. When the surface begins to set up, trowel it vigorously with a steel trowel to a smooth, hard finish. Finish the roof by applying hot asphalt and paper in the same way you put roofing on any concrete roof. Permit the roof slab to dry thoroughly before you apply the roofing. The roof pitch must be rather flat to permit pouring the concrete. On steeper pitches, pour the slab in sections on the ground or in the shop and lay them in place when they are dry. A good width for these sections is 48 inches, so it can span rafter spacing of 24 or 16 inches.

We do not recommend pouring a wall or floor in larger than 10 foot sections without the use of expansion strips. Although we have had no difficulty with shinkage or expansion, no one has yet had enough experience with this material to recommend placing large sections without making provisions for shrinkage or expansion.

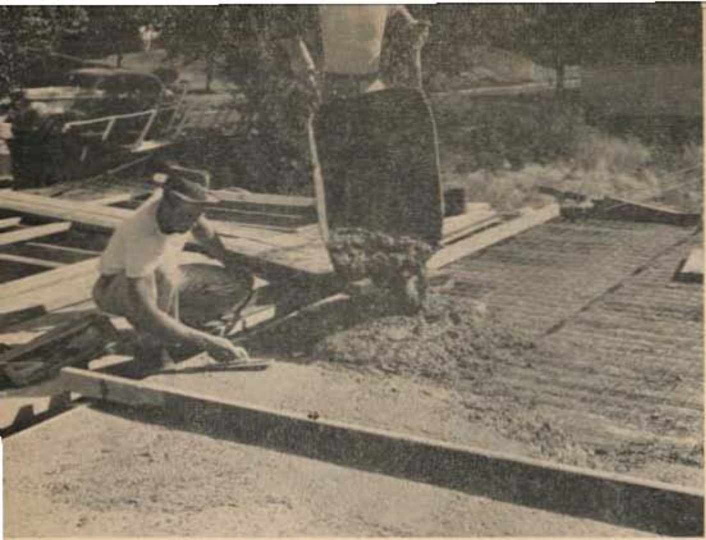
PROPORTIONING

You may vary the relative amounts of cement, diatomite, clay, and sawdust or shavings so that the resultant concrete has the characteristics desired for a particular use. The table on page 7

COMPRESSIVE STRENGTHS OF CONCRETE MADE OF CEMENT, SAWDUST, DIATOMITE, AND CLAY.



Lightweight concrete has ample strength for ordinary building purposes.



Pouring a floor slab of light weight concrete. The steeltex on which the concrete is poured serves as a form and for reinforcement.

gives the strengths of 12 different mixes, and these may be modified to obtain other strengths. Do not use more clay than cement in any mix. You may use more diatomite than cement, and the concrete will be slightly stronger and more workable, but do not use more diatomite than twice the volume of cement. The amount of sawdust should be at least twice the volume of the clay and diatomite combined. Less sawdust than this will result in a stronger concrete, but it will be heavier and less insulative and will have little value as a lightweight and insulative concrete.

USES

We recommend the use of this concrete in walls needing good insulation but not having high strength requirements. It may also be used in floor and roof slabs. The concrete can be poured in place, or cast into blocks and laid up into a wall.

We do not recommend this concrete for use where it will be directly exposed to the weather. This material is new, and we have not yet fully determined its limitations and capabilities. We have had test slabs exposed to the weather for 2 years and have made speeded up tests under artificial conditions without evidence of deterioration thus far. Only long time tests will tell us its resistance to weathering. You may saw, drill, or chisel this concrete. It may be nailed, although the nail-holding power is less than for most woods. The concrete takes either oil paint or cement-water paints, and you can apply plaster directly to it.

Our concrete's moisture absorption is high, and we recommend a vapor barrier where conditions are such that condensation is likely to be a problem in or on the wall. This is standard practice for any insulating material.

Diatomite concrete weighs about 50 pounds per cubic foot—1/3 the weight of sand-gravel concrete—so the size of footings or any structural members carrying it may be reduced accordingly.

It will not burn, the fire resistance varying with the strength. A lean mixture which produces a weak concrete will weaken more under fire than a stronger mix.

The information given here is general and insufficient for engineering or architectural design calculation. A bulletin containing accurate data presented in a more technical manner is in process of publication and will be available soon. If you need a copy write the "Department of Agricultural Engineering, University of Idaho, Moscow, Idaho." There is no charge for the bulletin.

We have used this cement-diatomite-clay-sawdust concrete in constructing a Moscow residence. The construction was not part of the research project, but all procedures were observed and data carefully recorded. This building is still under observation as it is a full-scale test of the capabilities of this material. The construction is of brick veneer backed with 5 inches of pre-cast wood fiber concrete with plaster applied directly on the inside wall. Floors are built of 3½ inches of this material topped with ¾ inch of sand concrete. The roof is also a slab of this material 3½ inches thick and covered with built-up roofing. The cost was considerably less than for a more conventional construction but seems to be structurally equal to conventional construction and superior to it in many ways.

ISSUED IN FURTHERANCE OF THE ACTS OF MAY 8 AND JUNE 30, 1914. COOPERATIVE EXTENSION SERVICE IN AGRICULTURE AND HOME ECONOMICS OF THE STATE OF IDAHO, UNIVERSITY OF IDAHO EXTENSION DIVISION AND UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING.

IDAHONIAN, MOSCOW