

Outdoor Home Improvement

With spring thaw come thoughts of upgrading the home grounds to a suitable setting for outdoor activities. Here's our annual section of ideas you can adapt to your own house and yard to make this a summer to remember.

Soil-cement paving —almost concrete-tough at a fraction of the cost

By RICHARD DAY

Yes, you can make durable paving—even building blocks—out of dirt. With dirt and a little cement you can install a patio, driveway, or walkway that will last through inclement weather and family traffic. And you can do it without dipping deeply into your coffers. So if you're planning to pave, consider the virtues of soil-cement.

Its basic material, dirt, is certainly abundant and priced right. While concrete contains roughly 25 percent cement and calls for highly select aggregates, soil-cement can be made with as little as eight percent cement and plain earth. A 20-by-25-foot soil-cement patio will cost about \$150, roughly one-fourth the cost of paving with concrete.

Although soil-cement develops only about one-half the strength of concrete, that's sufficient for most foot and automobile traffic. But soil-cement will give you something that concrete and asphalt can't: a pavement that blends in with the surroundings. Soil-cement resembles nothing so much as the dirt it's made from, so your project will have a more natural look.

You probably won't need to drag in a special soil for soil-cement. Most soils below the uppermost layer will work just fine, particularly sandy or gravelly soils, in which the aggregates are already present. In fact, there are few types of soil that won't yield good soil-cement. Soil that contains organic

(vegetable) matter—and you can diagnose this by the presence of a musty smell—won't react well with cement. Dark topsoil and clay require so much cement that they're impractical for soil-cement.

Out of the yard...

There's nothing revolutionary or untested about the stuff. I built a soil-cement basketball pad 11 years ago [PS, Sept. '73], and it's still in good condition. But soil-cement hasn't been confined to backyard projects. In fact, it's found a home in civil-engineering projects in which strength, cost, and durability are primary considerations.

You can drive over soil-cement roads in Edmonton (Alberta, Canada) and in California's northern Modoc County. Soil-cement has been used successfully in dams, airport runways, canal linings, and many other applications for which concrete has usually been the material of choice.

Despite its own success with soil-cement, the Portland Cement Assn. hesitates to recommend it for do-it-yourselfers. Its reluctance stems from the fact that soil-cement requires great attention to detail, particularly because there are no exact numbers to govern the percentage of cement to be used: Every soil must be tested thoroughly to arrive at an optimum percentage of cement.

My experience indicates that there's no reason to be intimidated by the hesitancy of the PCA. If you're willing to be patient, to run the necessary soil tests (see box), and to tend

to all the details of mixing, tamping, and curing, there's every reason that soil-cement should work for you.

The key to success with soil-cement is in determining the right percentage of cement by volume to be mixed with your soil. To find that number, you've got to run some tests. Soils engineers have a battery of standardized tests for soils, but to understand them you have to be well acquainted with terms such as liquid limit, plasticity index, and Poisson's ratio. The PCA has devised a reliable, simple method for testing soils. The "pick-and-click test" allows you to determine the optimum percentage of cement needed for your soil-cement.

The results of a PCA test will also warn you against using soil-cement, even if your soil is a type that should react well. If your optimum cement content is 20 percent, reconsider; you won't be saving much money over using concrete.

Once you've determined the optimum percentage of cement and decided on the necessary depth of soil-cement paving, you can calculate the number of bags of portland cement you'll need for your project. (One bag of portland cement contains exactly one cubic foot of cement.)

Paving for patios, basketball courts, and floors—any area that will support only foot traffic—needs four inches of soil-cement. Driveways and sidewalks that a car will cross need five inches. Garage floors and driveways for light trucks take six inches (heavy-duty

Continued

trucks call for nine). Add an inch for severe freeze-thaw climates.

Multiply the length, width, and depth (all in feet) of your project by the percentage of cement needed for optimum soil-cement. For example, if you're planning a 12-percent cement walk that's 20 feet by four feet by five inches (0.42 ft.), figure on using four bags of cement ($20 \times 4 \times 0.42 \times 0.12 = 4$).

Next, mark the project off into grids, following the guidelines in table C. If you've determined, for instance, that your optimum volume of cement is 12 percent and your project calls for soil-cement six inches deep, one grid will encompass 17 square feet. As you might suspect, the thicker the pav-

ing and the higher the percentage of cement, the smaller the rectangles. Grids ensure an even, correct cement spread because each grid will take one bag of cement.

Empty the bags of cement onto their respective grids and spread with a rake. Use a rotary tiller to mix the soil and cement. (Mixing by hand is far too difficult; besides, you'll need to conserve your strength for tamping.) Rotary tillers can be rented for about \$30 a day, which should be enough time to finish a job.

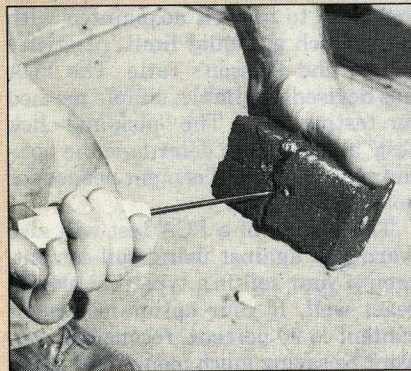
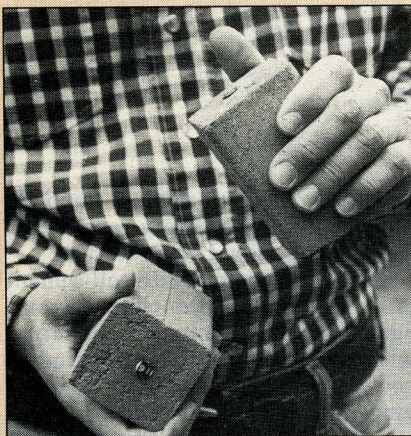
As you mix, bear in mind that it's easy to mix too deeply and that this produces weak soil-cement because the cement will be mixed with more soil than intended. Wrap a piece of tape

around each tiller tine to help guide you to the desired depth.

Mix until the soil and cement form a uniformly colored mixture and the lumps are gone. You can leave in rocks that don't interfere with the tilling. To test for uniformity, drop a shovel into the mixture to below your desired depth and expose a cross section. Tilling fluffs up the mixture to what's called its loose depth. The thickness of paving that you chose is based on loose depth, not final product, so check the depth of the mixture while you're checking the uniformity. Tamping will compact the mixture to approximately the soil's original grade.

Only if the soil was very wet to

Testing the soil: the pick-and-click test



What percentage of cement is correct for your project's soil-cement? To find out, you'll be running the Portland Cement Assn.'s pick-and-click test on a range of cement proportions four percentage points above and below what your soil typically needs (see table A). For example, if the soil is red dog, test eight samples at seven- through 15-percent cement. If your soil isn't included in table A or you can't find out exactly what type of soil you have, pick a median percentage for your starting point—testing a range of percentages allows for some guesswork.

Gather 10 samples of the project soil from various points, and mix these in a pail. Using a film can or any other container, portion cement and soil into a form, following the guidelines

of table B to arrive at the correct proportions. I recommend using four-inch lengths of three-inch-diameter plastic pipe or downspout cut-offs for forms. I also recommend sticking colored thumb tacks into the forms to identify which sample represents which percentage of cement.

Mix each sample batch to break up the lumps, then add water until you reach what's called the optimum moisture content. Too much or too little water means that the soil won't reach maximum compaction or maximum hardness. Unless the soil reaches these last two states, the results of the pick-and-click test won't be reliable—and neither will your paving.

Test for optimum moisture content by first squeezing and releasing a handful of the mixture. You should be able to hold the molded soil by one end without its breaking. If the mixture's too wet, water will be left on your hand; too dry, and it won't stay together. Let the mixture dry if it's too wet. Don't add soil—you'll be altering the percentage of cement.

Next, make a ball of the mixture in your hand and drop it from waist height. If it shatters, it's OK; if it stays together, it contains too much water. When your soil has reached optimum moisture content, you can make test samples.

With the butt of the handle of a heavy hammer, tamp the soil-and-cement mixture in three stages, one layer at a time. After you tamp the first and second layers, rake over them with the hammer claw. This ties the layers together and eliminates compaction planes that would weaken the sample. Let the samples sit for seven days.

The pick-and-click test calls for the week-old soil-and-cement samples to be tested first after they've soaked in water for four hours and again when they've dried. But before you remove the soil-and-cement samples from their forms and immerse them, they must reach maximum compaction.

Start with the sample with the lowest percentage of cement, and jab it lightly with a dull ice pick. If the sample resists, jab harder. If it withstands blows swung from shoulder height yet holds penetration to between $\frac{1}{8}$ and $\frac{1}{4}$ inch, it passes the pick test. Test the remaining samples.

The click test consists of knocking two samples together, gently at first. Start with the samples lowest in percentage of cement. A dull thud indicates that at least one of the samples isn't hard enough. Increase the knocking force.

If a sample breaks across but the broken face passes a pick test, it's fine. When the surviving samples have dried, retest them.

Take the sample with the lowest percentage of cement that has passed the pick-and-click test as your starting point. Then add four percentage points: For fully exposed surfaces, the optimum percentage of cement is four points above the starting point. For example, if the test yields a 10-percent sample, use a 14-percent mixture.—R. D.

Table A: typical cement content for various soils

Soil	Cement content (percentage by vol.)
Sandy or gravelly	10
Heavy with clay	12-14
Caliche	10
Chat	11
Cinders	11
Marl	14
Red dog	11
Shale or disintegrated shale	13
Shell	10

Table B: test-batching for cement content

Percentage of cement	Parts cement	Parts soil
5	1	20
6	1	16 $\frac{2}{3}$
7	1	14 $\frac{1}{4}$
8	1	12 $\frac{1}{2}$
9	2	22 $\frac{1}{4}$
10	1	10
11	1	9
12	1	8 $\frac{1}{3}$
13	3	23
14	2	14 $\frac{1}{4}$
15	1	6 $\frac{2}{3}$
16	1	6 $\frac{1}{4}$
17	2	11 $\frac{3}{4}$
18	3	16 $\frac{2}{3}$
19	1	5 $\frac{1}{4}$
20	1	5

Beginning here . . .

"Foot-Heaven House" use airspace between outer and inner roof to vent hot air in summer (bottom left). In winter, roof becomes inefficient but giant solar collector (top left) heat trapped air in space is delivered to house. Paint-gels involved can be applied to houses of many sizes and styles (far left).



Soil-cement paving in these two California state parks has withstood considerable traffic and varying weather conditions. The paving also blends in with rustic setting (photos above). DIY soil-cement can be equally successful. Once optimum percentage of cement is determined, divide project into grids (top photo) so that one grid corresponds to one bag of cement. Empty cement bags, and till to mix soil and cement to necessary depth (right).



Non-slip concrete

If you live in the Sun Belt, you can put an attractive non-slip texture on concrete walks, driveways, patios, and pool aprons. Just sprinkle rock salt over the freshly floated slab, and trowel it in, as shown in the photo below. Or immediately refloat the fresh concrete until the crystals are just below the surface. Later, after the concrete has hardened, the chunks of salt will wash out, leaving pockmarks over the surface (bottom photo).

Why is this treatment limited to the Sun Belt? In freeze-thaw climates, an "open" finish like this invites fast deterioration of the surface—even if you use freeze-resistant air-entrained concrete. Go the exposed-aggregate route instead.—*Richard Day*

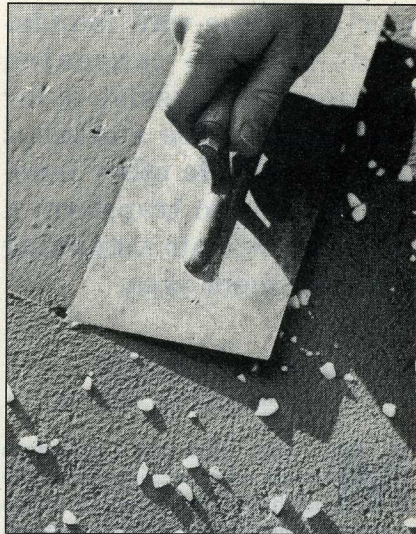


Table C: soil-cement spread

Percentage of cement	Grid area (sq. ft.)			
	4 in. deep	5 in. deep	6 in. deep	9 in. deep
8	38	30	25	17
10	30	24	20	13
12	25	20	17	11
14	21	17	14	9½
16	19	15	12	8
18	17	13	11	7½
20*	15	12	10	6½

*Consider bringing in a better-acting soil.

begin with, such as right after a rain, will it contain sufficient water to create soil-cement at optimum moisture. Most likely, you'll have to add water with a garden-hose spray.

Add a little water at a time, and continue testing the soil for moisture content by the hand-squeeze test (see box). You might be tempted to just spray water and hope. Resist. Too much water will weaken the soil-cement; too little will result in strong soil cement—until the first rain.

Hand tamping, the next step, is tiring, and with soil-cement you've got to compact every square inch. If you're hand tamping, don't tackle more than about 75 square feet a day per worker. Of course a power tamper will save on muscle ache.

Keep tamping until you've created a dense surface. Try as you may, you cannot over-tamp soil-cement, although if you tire you can certainly under-tamp. To get a smooth, even finish, scratch up some loose surface soil with a rake and smooth it out before the final tamping. Then set your garden hose on fine spray to smooth out tamp marks.

You don't have to mix and tamp out the entire project in a day. If the project is large, complete it in sections. Just make sure that whatever has been spread out and mixed has been tamped. When you begin work again, till an inch or two along the joint between the old and new portions to establish a tie between them.

Soil-cement, like concrete, needs moist curing to gain full strength. I recommend covering the area with a sheet of plastic or a canvas tarpaulin to keep the moisture in. If you elect to sprinkle-cure, however, make sure you just dampen the area slightly on the first day. Soil-cement needs five days to cure completely.

There are other uses for this durable material. Soil-cement walls can be built by making blocks, piling soil-cement into forms ["He Builds High-Tech Rammed-Earth Houses," PS, Nov. '82], or packing it into sandbags. And interior floors of soil-cement have some of the resiliency of suspended wood floors along with the thermal-storage capacity of a slab. PS



To check mixed depth, expose a cross section with spade (top photo). Measure down to unmixed soil, which will differ in color from soil-cement mixture. Begin tamping when soil-cement is at optimum moisture content; the ideal tamper has a face size of about 10 square inches. Proper tamped density is reached when the surface resists impressions of the tamper (center photo). Moist curing (above) is essential for soil-cement, just as it is for concrete.