

Using Soil-Cement on Horse and Livestock Farms

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Most farmers in Kentucky can identify with a myriad of problems associated with mud forming around high traffic areas, including areas around horse and cattle waterers, feed bunks, round bale feeders, walk paths and gate entrances. Mud is usually a result of animals congregating in and around these areas, but increased traffic can enhance the problem. In many cases, finding solutions to mud problems on farms is not the issue—the issue is determining how to make solutions economical.

Concrete and heavy traffic pads are traditional remedies for reducing mud on horse and livestock farms. A non-traditional option is soil-cement, which is about one-third the cost of concrete. Soil-cement is a highly compacted mixture of soil, Type 1 Portland cement and water. Soil-cement was originally used as a stabilizing agent for river banks, and has since been used as a subgrade and subbase modifier for roadways, water retention structures and dam construction. Agricultural uses of soil-cement in Kentucky have been in smaller areas, such as around automatic waterers and feed bunks, horse paths and gate entrances. In these areas, soil-cement has been beneficial in stabilizing the soil around the area and preventing mud.

Laboratory tests show completed soil-cement mixture is suitable as a livestock heavy traffic pad material, because it will form a hardened, stiff and durable material. To demonstrate soil cement, an area around an automatic waterer was selected (Figure 1). In the past, soil around this waterer had to be replaced every three years with approximately six to nine inches of soil. The success of soil



Figure 1. A typical waterer and concrete pad used in agriculture.



Figure 2. The stability and wear of a watering pad area treated with soil cement two years prior.

cement as a heavy traffic pad material is illustrated in Figure 2, which shows the stability of the watering area after two years of exposure to the horses and the elements. This document describes the process of how to install soil cement areas.

Materials

The amount of cement needed to construct a pad varies depending on the type of soil with which it is mixed and its intended use. As a base treatment for highways and roads, a 4 percent cement mixture of soil-cement has been used successfully. However, as a surface treatment (as on most farms), the cement percentage should be increased.

Proper mixing when preparing soil-cement is crucial. Improper mix amounts can lead to inferior soil-cement and can cost extra money. Research shows that a mix with 6 to 15 percent cement by weight will provide an adequate ratio to construct a proper pad. A more in-depth method for determining mixture content can be found by using Table 1.

To properly use Table 1, consult a soil survey book for your county, or use the Web Soil Survey (<http://websoilsurvey.nrcs.usda.gov>). Soil survey books are compiled for specific counties and contain soil survey maps and engineering properties tables for those areas. For example, the University of Kentucky has a farm in Woodford County and the soil survey map shows a MiB soil (Maury silt loam on 2 to 6 percent slopes) for one area of the farm. The engineering prop-

Table 1. Cement requirements for different soils.

Soil Classification		Typical range of cement requirement (% by weight)
AASHTO ¹	ASTM ²	
A-1-a	GW,GP,GM,SW,SP,SM	3-5
A-1-b	GM,GP,SM,SP	5-8
A-2	GM,GC,SM,SC	5-9
A-3	SP	7-11
A-4	CL,ML	7-12
A-5	ML,MH,CH	8-13
A-6	CL,CH	9-15
A-7	MH,CH	10-16

¹ American Association of State Highway and Transportation Officials
² American Society for Testing and Materials

erties table contains the classification of this soil, which is located under the label AASHTO (American Association of State Highway and Transportation Officials). This particular MiB soil is an A-4. Table 1 demonstrates the amount of cement needed.

For the A-4 soil, cement requirement typically ranges between 7 to 12 percent. The 7 to 12 percent ranges are guidelines for cement use. A 7 percent mixture may be sufficient for a light traffic pad, but for our example we expected our pad to receive a high volume of traffic. Therefore, 12 percent was used.

To calculate the number of bags of cement needed, use Equation 1. Assume your lengths and widths are in feet, your depths are in inches and you have a cement density of 97 lb/cu ft. See Example 1 for how to calculate the number of cement bags needed to construct a soil cement pad that measures 10 foot by 15 foot by 5 inches deep, and assuming that you will use 94-lb cement bags.

For a long-term pad on a general farm, 6 to 15 percent cement by dry weight is needed. Adding a small size aggregate to the soil before adding the cement is a good way to strengthen the soil-cement while adding traction. Class I sands, or limestone sand, are a good size that can still be incorporated into the soil.

To make soil-cement effective, some guidelines must be followed. The area planned for improvement, regardless of its history, should be free of all organic matter. All grass, weeds, sticks, stumps and manure must be scraped off and replaced with fresh soil (if needed) (Figure 3). Rocks can be a beneficial additive to soil-cement. It is not required to completely rid the area of rocks, as rocks can add to the strength of the soil-cement. However, rock that is too large can lead to poor compaction. A recommended rock size is found in dense grade aggregate (DGA) or Class I sand.

Equation 1.

$$l \times w \times \frac{d}{12} \times \frac{\%}{100} \times Pc \div s = \#$$

- l = length (ft)
- w = width (ft)
- d = depth (in)
- % = Percent cement (from Table 1)
- Pc = density of cement (97 lb per cu ft)
- s = Cement bag size (lb)
- # = Number of bags needed

Example 1:

$$10 \times 15 \times \frac{5}{12} \times \frac{12}{100} \times 97 \div 94 = 7.7$$

= 8 bags needed

Construction

Equipment needed to complete site preparation:

- A garden tiller (self-propelled or tractor power take-off driven)
- A tractor with a loader
- A vibratory rolling compactor
- A water source

1. Use the tiller to pulverize the soil.

More than one pass of the tiller may be required to reach the consistency of a seed bed. Use caution; do not till beyond desired depth. Loose soil makes adding rock easier, if desired.

2. Add a smooth layer of rock over the loosened soil on a one-to-one (or less) basis by volume. Use Equation 2 to estimate the amount of rock to be applied. Once rock has been spread, make a couple more passes with the tiller to sufficiently combine the two ingredients.

3. Once a uniform and solid foundation for the soil-cement has been prepared, spread cement over the soil and rock mixture. The cement must be more evenly spread than the rock. If bags of Portland cement will be used, space the bags evenly before emptying them. Once the cement has been spread, make one or two slow passes of the tiller to mix the materials together to form a desired blend.

Equation 2.

$$l \times w \times \frac{d}{12} \times Pr = R$$

- l = length (ft)
- w = width (ft)
- d = depth (in)
- Pr = density of rock (100 lb per cu ft)
- R = rock needed (lb)

Example 2:

$$10 \times 15 \times \frac{5}{12} \times 100 = 6,250$$

= 6,250 lb rock needed

Note: Limestone rock (common in Kentucky) is estimated to have a density of 100 lb/cu ft.

4. Add water to the soil-cement mixture.

To ensure uniform water content throughout the soil-cement, water should be added to the mixture while it is being tilled. There are two quick field tests to determine if the correct water content has been reached. One is to pick up a small amount of the mix and form it into a ball in your hand. The resulting ball of mix should hold its shape and not stain your hand. You should be able to pull the ball apart without it disintegrating. The second test is to form a small amount of mix into a ball and drop the ball from about 10 inches onto the tilled ground. If the ball of mix can be picked up again, the water content is appropriate.

5. Compact the soil-cement mixture. To ensure a completed soil-cement layer with the highest strength and durability possible, compact with a vibratory sheep's foot roller. Compact the soil-cement mixture until the surface no longer pumps, ruts, shoves, mars or otherwise deforms under the weight of the roller. If a smooth surface is desired, a smooth drum roller may be run over the surface after the sheep's foot roller. At this point, the soil-cement is ready to be cured.

To ensure that the soil-cement does not dry too quickly from high temperatures or wind, it is important to keep

the surface continuously moist until it has fully cured (Figure 3). Although precipitation before all ingredients are mixed may be detrimental, rainfall on a compacted soil-cement layer will serve to aid in the curing process. Be careful not to use a sprinkler with too much force to avoid disturbing the uncured surface. Plastic covering may be used



Figure 3. A 360-degree sprinkler is one way to keep the soil-cement wet.

on small areas to inhibit the soil-cement from curing too quickly. Soil-cement should only be constructed when the outside air temperature is 40° F or above and should never be constructed with muddy or frozen materials.

After a typical curing period of two or three days has passed, the soil-cement may be top dressed with 57's (course aggregate with a 100 percent passing through 1.5 inch screen), Dense Grade Aggregate (DGA), Class I sand (crusher fines), or it can be left exposed. Top dressing depends on the operator's judgment. At this point, the soil-cement should be sufficiently cured to support animal and equipment traffic (Figure 4). If the area is small enough to top dress without equipment moving onto freshly compacted (uncured) soil-cement, feel free to do so. Top dressing will help keep moisture in the soil cement during the curing period.

Further Reading

High Traffic Area Pads for Horses (ID-164) at www.ca.uky.edu/agc/pubs/id/id164/id164.pdf.

Using Dry Lots to Conserve Pastures and Reduce Pollution Potential (ID-171) at www.ca.uky.edu/agc/pubs/id/id171/id171.pdf.



Figure 4. Horses on a soil-cement pad top dressed with Class I sand.

