

Appropriate All Weather Surfaces for Livestock

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Many livestock producers would say that mud is a natural part of livestock production. But the creation of mud costs producers money and makes them less competitive. Livestock that walk through mud require more feed for energy but actually eat less because walking in mud requires more effort to get to feed and water. Therefore, mud decreases average daily gains (Table 1). Mud accumulation on the coat increases the amount of energy needed to generate heat in the winter or to keep cool in the summer. Also, it can lower sale prices due to hanging tags. The creation of mud also increases animal stress and leads to a variety of health problems, including protozoan and bacterial infections. It is essential that livestock producers understand that mud hinders cost-efficient livestock production and efforts should be made to limit the creation of mud. This publication explains how mud is created and describes different types of hardened surfaces and pads that agricultural producers should use to reduce mud creation and ultimately increase production efficiency and protect natural resources.

Mud can cause soil to move off-site as runoff or erosion. When erosion happens, the topsoil, or the most productive portion of the soil for crop yields and filtration, is lost. After erosion occurs, a compacted clay layer and rocks that are only able to support weeds are all that remain. While fertile topsoil is of great value on the farmstead, it can act as a physical water contaminant when taken off-site by erosion. In addition, it will carry pathogens, nutrients, and other contaminants attached to the soil particles.

Hardening heavily-used livestock areas can decrease the creation of mud, create an area that is easier to maintain, reduce the amount of feed wasted and required by livestock, and save time and money by eliminating the need to renovate bare areas. Recent research has shown that an average of 60 percent and as much as 90 percent of fed hay can be wasted if livestock are fed on muddy surfaces with no feeding structure. Wasted forage can cause supplemental feed costs to rise dramatically and actually cause weight loss instead of gains (Martinson et al., 2012). Hauling and spreading feed

on unprotected topsoil using tractors and other farm equipment will cause further rutting and mud generation.

Mud Creation

When an animal is standing, it applies a certain amount of pressure to a surface. The standing pressure for several animals and farm equipment, measured in pounds per square inch (psi), is shown in Table 2. From the table, it is clear that the foot pressure of standing cattle and horses places about 66 percent more pressure psi than a 50-ton dozer! For livestock producers who have been in operation for years, this point has likely been demonstrated already through visible field damage and soil compaction. Table 3 shows the foot pressure for walking livestock, which shifts their weight to two feet rather than all four. This means more pressure is applied when the animal is moving, causing increased damage to the topsoil. Moreover, when an animal walks slowly and repeatedly over the same area, as is common in feeding and watering areas, it will sink deeper into non-cemented materials, possibly up to their knees and hocks (Figure 1).

Table 4 provides information on the amount of strength various farm surfaces can provide before they fail. These data are for dry materials. It is important to note that applying moisture to these surfaces, as in the form of precipitation, will weaken non-cemented (natural) materials. When comparing the foot pressure of large livestock like cattle and horses to the resistance strength of typical topsoil, it is clear that these surfaces do not provide the strength needed to support the weight of the animals and heavy equipment traffic, especially if they become wet. To reduce the creation of mud and erosion, producers need to provide livestock with a sufficiently hard surface they can stand on that can support their weight.

Improved surfaces, even those as easy to install as compacted gravel, have sufficient strength to support the needs of a successful livestock operation. The strength data for these improved surfaces explain why the National Resources Conservation Service (NRCS) recommends heavy use area pads for lanes, and feeding, and watering areas. Producers that

Table 1. Effects of Mud on Cattle

Mud Depth (in.)	Total Feed Required (%)	Feed Intake (%)	Daily Gains (%)
4-8	+12 -13	-8 to -15	-14
12-24	+20 - 25	-30	-25

* Adapted from the Alberta Feedlot Management Guide.

Table 2. Pressure Created by Different Stressors

Stressors	Pressure (psi)
Sheep	12
Human	14
Utility terrain vehicle	14
50-ton dozer	16
Cattle	27
Horse	27
Tractor	175

Table 3. Pressure created by walking humans and livestock

Stressors	Pressure (psi)
Human	28
Cattle	48
Horse	48

Table 4. Load Carrying Capacities of Different Livestock Surfaces

Type of Surface	Pressure (psi)
Soft clay or sandy loam	14
Firm clay or fine sand	28
Dry clay or compact fine sand	42
Loose gravel or compact coarse sand	56
Compact sand and gravel mixture	83
Soil cement (12% mixture)	2,400
Concrete (6-inch reinforced)	6,000

use these surfaces are able to be more competitive because of the long-term cost-savings of the improvements (Table 5). These surfaces are also cost-shared using taxpayer dollars, because they protect environmental resources, which is why they are considered an agriculture water quality best management practice (BMP). Hardened surfaces or pads should be used in stream crossings, laneways, feeding areas, around waterers, gateways, and anywhere animals congregate.



Figure 1. An unimproved surface area with tire rutting, wasted feed, and poor walking conditions for cattle.

Table 5. Annual costs of various surfaces used on livestock operations

Cost Item	Unimproved (\$)	Gravel (\$)	Geotextile (\$)	Concrete (\$)
Total annual fixed cost on investment	0	2,187	1,383	3,450
Total annual operating cost	500	1,238	1,050	300
Total annual indirect costs	4,481	0	0	0
Total annual costs	4,981	3,425	2,433	3,750

Siting

When constructing hardened surfaces for feeding, watering, or other uses, producers need to consider the location of the pad in relation to sensitive environmental resources. Technical assistance from the NRCS for siting and design is available to producers. The NRCS will use their set of standards to help determine the best placement for a heavy use surface. There are exceptions, but in most cases hardened surfaces should be placed on a summit. This position will provide adequate distance from most environmentally sensitive features (i.e. streams, floodplains, etc.) and allow surrounding

vegetation to filter stormwater runoff before it reaches these areas. The pad needs to be placed on a sloping area to promote drainage away from structures like feed bunkers and waterers. The drainage should not flow onto an impervious area, like a roadway, which can allow the runoff to travel greater distances.

One notable exception to the avoidance of locating hardened surfaces in environmentally sensitive areas is the creation of a designated hardened stream crossing for livestock. Installing stream crossings is a BMP that can reduce streamside erosion. For stream crossings, concrete should be avoided and only gravel surfaces with geotextile fabric

should be used. Over time, the constant force of the stream flow may undercut the placed concrete and then the section becomes more of a hazard to livestock than a service. For more information on stream crossings for livestock see the University of Kentucky Cooperative Extension publication *Stream Crossings for Cattle* (AEN-101).

Subgrade and Site Preparation

Topsoil does not provide adequate strength to support the long-term maintenance of a hardened pad. To provide an adequate foundation for the pad, the existing topsoil and vegetation must be removed to develop a base that is uniform in soil type, compaction, and moisture content. If fill is needed to provide reinforcement or drainage, a sub-base consisting of compacted gravel should be used. Make plans for where this excess soil can be used most effectively or sold to generate funds for the project. The

ideal width for a feeding area depends on stocking density and the location of buildings, structures, water sources, or gates in the adjacent area and should be made on a case-by-case basis.

Materials

Livestock producers have many choices when it comes to surfaces suitable for minimizing the creation of mud (Table 5). This publication discusses several commonly used surfaces, but is not comprehensive. Other surfaces could be used, and as with the materials described in this publication, the efficiency depends on the availability of the material, installation costs, and the size and scope of the operation.

Concrete

Concrete has the highest strength of any of the surfaces used in livestock production, is easy to clean, and requires virtually no maintenance. Although the initial expense of concrete is high compared to other surfaces, using an unimproved area ultimately costs more because of indirect costs like additional feed and reduced gains (Table 5). On livestock operations, concrete should be used in areas that typically receive heavy animal traffic, including around waterers, and possibly adjacent to feed bunks and in holding areas. Recommendations on the size and thickness of the pad vary depending on type of livestock and ultimate purpose, but usually a minimum thickness of 4 inches is needed. If heavy trucks and tractors are going to be on the pad, then 5 to 6 inches is preferred.

For the construction of concrete pads, an adequate foundation must first be prepared by removing all topsoil to a level of compactable soil. For pads that are going to be subjected to heavy loads, a minimum of 6 inches of compacted dense grade aggregate (DGA) should be placed to provide base support for the concrete pad. Examples of concrete placed without an adequately prepared foundation are shown in figures 2, and 3. A preferred method for installing concrete pads, such as these, is to extend heavy use area pads beyond the concrete (Figures 4, 5, and 6). Inadequate foundation preparation can lead to concrete pad failure and/or frozen or damaged water pipes.



Figure 2. Poorly constructed foundation for a concrete pad.



Figure 3. Poorly constructed foundation for a concrete pad that could create too much air flow, which could freeze water pipes.

Geotextile Fabric and Rock

Geotextile fabric and rock are often recommended to reduce mud generation and limit erosion. For agriculture, geotextile fabric and rock provides a cheaper surface than concrete, can extend the working lives of structures, improve livestock production, and protect the environment. Figure 4 provides an example of the improvements that can be made to a heavy traffic feeding area using geotextile fabric and rock.

Geotextile fabrics are known by many different names (geotextiles, filter fabric, cow carpet, erosion control fabric, and mud control fabric), but should not be confused with geosynthetics, which are often used to establish vegetation.

There are two major categories of geotextile fabric: woven and non-woven. Woven fabrics are composed of strands of material that are woven together to form a fabric. By nature, these woven fabrics provide varying degrees of filtra-



Figure 4. Example of a feeding lot using geotextile fabric and rock.

tion. Non-woven fabrics (heat bonded and needle punched) are composed of a continuous sheet of felt-like engineered material. Needle punched fabrics provide filtration, but are generally not as strong as woven fabrics.

Geotextile fabric can be used for many applications on livestock operations including filtration, separation, drainage, erosion control, sediment control, and structural reinforcement. Essentially, geotextile fabric is designed to separate materials, such as rock from soil, and soil from water. For example, when used to stabilize a farm road or heavy traffic pad, geotextile fabric creates a separation between the rock and soil interface, providing integrity and extending the life of the pad. It also provides reinforcement by distributing loads over a larger area, and filters water through while keeping soil intact. Using this low-cost system creates a long-lasting structure and preserves natural resources by reducing erosion.

A combination of materials can be used together to satisfy different needs in the same area (Figures 5 and 6). For



Figure 5. Adequately designed concrete pad, foundation, and heavy use area pad constructed of concrete, geotextile fabric, and rock.

example, geotextile fabric and rock can be installed in gated entrances adjacent to concrete pads or on approaches leading off pads to address mud holes and depressions.

When constructing a high traffic pad with geotextiles, first clear the site and dig a trench along the edges to provide a clean block for placing the fabric. This prevents the fabric from being exposed



Figure 6. This picture shows two surfaces to support livestock: a concrete surface for feeding cattle and scraping and a heavy use area pad made of compacted rock and geotextile fabric.

to the surface, which could cause the fabric to degrade in sunlight or unravel when the pad is cleaned. After the site is prepared, stretch the fabric so that there are no wrinkles. Wrinkles prevent adequate distribution of loads and could compromise the pad. Pads larger than a single width of fabric (12 feet) should be laid so that they overlap by at least 2 feet. Ideally, rock should not be dropped onto the fabric from a distance greater than 3 feet to prevent damage to the fabric. Most importantly, use caution when dumping the first loads of rock to avoid ripping or wrinkling the fabric. If the fabric is wrinkled or damaged, it will not be as effective as a reinforcement material. Dense grade aggregate (DGA) should be added over the base layer of rocks to provide a solid, stable surface.

Pad maintenance includes periodically top-dressing the surface with DGA, wetting it and then compacting it, so that the coarser sub-layer of rock is never exposed. The frequency at which surface rock must be reapplied depends on use and how aggressively the pad is scraped. For more information about constructing

a high traffic pad with geotextile fabric, refer to University of Kentucky Cooperative Extension publications *Using Geotextiles for Feeding and Traffic Surfaces* (AEN-79) and *High Traffic Area Pads for Horses* (ID-164),

Gravel Paver Grid

Gravel paver grid is a plastic, interlocking grid system that serves as a mold to retain gravel and reinforce heavy use areas. This reinforcing layer can help to reduce the volume of gravel that is lost during livestock confinement and manure scraping/recovery efforts (provides a solid stopping surface for a tractor or skid steer bucket). Gravel paver grid requires an initial installation of geotextile fabric and a minimum of 4 inches of compacted, dense graded aggregate. The gravel paver grid is installed on top of the newly created heavy use area and covered with an additional three to four inches of clean 1/2" gravel (Figure 7).

Other Materials

Although concrete is the strongest and most commonly recommended material for hardening heavy traffic areas, other

cement-like, pollution-free, products such as Flue Gas Desulfurization (FGD) material, fly ash, or soil-cement can also be used, often at a lower cost (Figure 8). These materials will be discussed in more detail later. Both FGD material and soil-cement pads can be installed for about one-third of the cost of concrete. However, when frequent scraping to remove manure deposits is anticipated, concrete pads are recommended because they are able to withstand the constant pressure and abrasion.

Pads made of FGD material, fly ash, or soil cement should be constructed between May and September to avoid freeze/thaw issues and to allow time for curing. FGD and soil cement pads should be cured for 28 days without cattle or hay present on the pad. Fly ash pads can be used immediately after construction in dry weather, but should be cured between 12 and 24 hours in wet weather. For more specific instructions about planning, constructing, and maintaining these pads refer to the references at the end of this publication and consult with a professional engineer.

FGD Material

FGD material is a by-product of a process typically used to reduce sulfur emissions from coal-fired power plants. The consistency of this material varies from a wet sludge to a dry powdery material. Once stabilized with fly ash and quicklime, the wet sludge material, commonly referred to as FGD filter cake, is gray and resembles silty clay. This enriched filter cake, when mixed at the power plant in proper proportions, provides a cement-like material that can provide a strong and durable surface. If the soil base is degraded, FGD material can be mixed with the soil and compacted to provide a stable base. When creating an FGD pad, be sure to compact each layer of FGD material (6 inches or less) to consolidate the material and obtain a uniform, solid surface of about 1 foot thick.

Fly Ash

Fly ash is a very fine powder that is also generated by coal-fired power plants. Nationwide, an estimated 60 million tons are generated each year, and much of this is placed in landfills. Using fly ash is both environmentally friendly and cost-effective for livestock producers, as it is often cheaper than Portland cement. The chemical composition of some fly ashes will cause it to cure in a way similar to concrete when water is added. The strength of the final product depends on the initial chemical composition of the coal and how it was processed. Because fly ash is powdery and can prove difficult to work with, it is recommended that producers use a ratio of 70 percent “bottom ash” (a less reactive filler product) and 30 percent fly ash to construct a heavy use area.

There are two ways to use fly ash to harden heavy traffic areas. The first is to mix fly ash with a clay soil, then mix in water, and compact the mixture in place. This method can produce a good surface, but it is difficult to do and generally not recommended. The second method is to build a fly ash pad on top of the soil. Adding an adequate amount of water and compaction is crucial to producing a long-lasting, functioning pad in both methods.



Figure 7. Gravel paver grid used to reinforce a barn floor where livestock will be confined.



Figure 8. A cattle feeding pad constructed with coal combustion by-products.

Soil-Cement

Soil-cement is a highly compacted mixture of soil, Type 1 Portland cement, and water. Proper mixing and material ratios are important for the long-term success of a soil-cement pad. A heavy traffic pad generally requires 12- to 15-percent cement mixture to withstand long-term

traffic. Adding a small aggregate, such as Class I sand or limestone sand, to the soil before adding the cement is a good way to strengthen the soil-cement while adding traction. Depending upon the conditions of the site and expected animal traffic, it may be a good idea to reinforce the area immediately around waterers with concrete and then surround the small



Figure 9. A soil-cement pad placed adjacent to a concrete pad for a waterer.

concrete pad with soil-cement (Figure 9). For more information about constructing a high traffic pad with soil cement, refer to University of Kentucky Cooperative Extension publication *Using Soil-Cement on Horse and Livestock Farms* (ID-176).

Gravel

Gravel alone can also be used in heavy traffic areas, but it does not last as long as concrete and requires more frequent maintenance, especially if not properly placed. Unlike other solid materials, the particles of gravel can runoff or become displaced from the intended area by precipitation, wind, and vehicle or foot traffic. A typical gravel pad should be approximately 12 inches thick to support livestock and farm equipment.

General Maintenance

No matter what type of hardened surface is used to prevent mud creation, there are some general maintenance practices that apply. First, manure should be scraped away periodically and stored in a covered manure stack pad until it can be land applied in the spring. In addition, if large amounts of runoff are generated by the impervious surface created, that stormwater should be managed and

redirected away from environmentally sensitive areas such as sinkholes, streams, ponds, or drainages.

The benefits of hardened surfaces for livestock operations are that they have the potential to increase production and profitability by decreasing mud. In many cases, the costs of installing all weather surfaces are outweighed by the benefits in production. In addition, these best management practices can add improve aesthetics and water quality, creating a more successful farming enterprise.

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