Racing Surfaces Testing Laboratory
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Loading of the Hind Hoof Track Loading

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Introduction

The 2000 pounds of force transferred from the front leg of the horse onto the track is often cited as the most extreme case for the loading of the track surface. However, the loading of the hind limb is also critical and may be more complex than the loading from the front leg. Since a horse primarily propels itself forward using its rear legs, not only does each leg sustain large vertical loads, but the leg, and therefore the surface, must also support propulsive forces or horizontal loading. In fact, when considering the performance of the horse, the hind limbs may be more important than the front limbs. In this technical bulletin, we discuss the force that the track surface must support for the safe performance of the thoroughbred horse at a gallop.

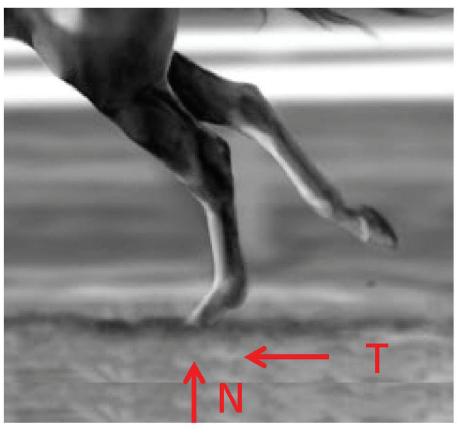

Figure 1: Forces in the tracks due to hind limb loading

Combined Vertical and Horizontal Loads

The two phases of the gait most relevant to the loading of the track are stance and breakover. During the stance phase of the gait, the hoof loads the soil with the entire dynamic weight of the horse, which may be divided between one or more legs at any moment in time. The track surface provides support for the hoof through normal force in the soil (N in figure 1), which may result in permanent or plastic deformation of the surface in the form of a hoof print as well as an elastic surface deflection that will rebound as soon as the load is removed. The amount of elastic response and the time it takes the surface to respond are sometimes referred to as "the bounce" or "the liveliness" of the track surface.

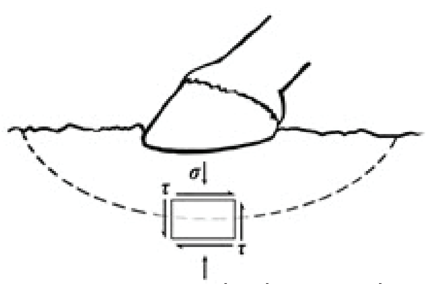

Figure 2: Stress in both axes is load divided by hoof area

The other critical phase of the gait for understanding the track surface is the horse's propulsion. During propulsion, the hind legs will push the horse forward with resistance or support provided by the racing surface. This force is horizontal, the shear force T in the figure 1, and is resisted by a supporting resistance to sliding in the track material. The force is applied over the area of the hoof to create a horizontal force per unit area, which is the shear stress, τ in the figure 2, or the vertical load per unit area which is the normal stress, σ, in the track surface. In synthetic, turf, and dirt surfaces, the support provided by the track surface may be measured by the resistance to failure due to shear stress which exceeds the resistance of one layer of the track material to sliding on the adjoining layer. In the case of a highly compacted material, slip may occur on the top surface - similar to friction of a shoe on a hard floor. However, the track is sufficiently soft that the hoof penetrates the top of the surface and the sliding of the material typically occurs below the top surface where the shoe is in contact with the track.

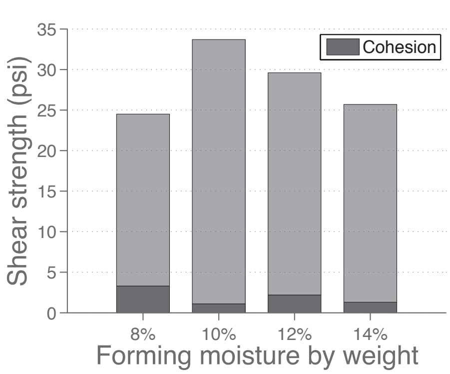

Figure 3: Dirt track material changes with moisture

Vertical and Horizontal Load and Soil Strength

The characteristic of the track that is of most interest for the support of the hind limb, both for safety and performance of the horse, is the shear strength. The

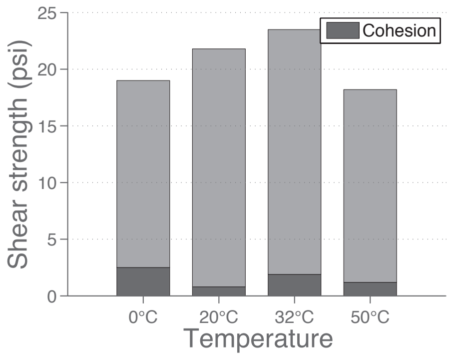

Figure 4: Synthetic track material changes with temperature

This technical bulletin is based on the white paper "Racing Surfaces," available at the Racing Surfaces Testing Laboratory website: racingsurfaces.org/white_papers and at the Jockey Club website: grayson-jockeyclub.org/resources/White_Paper_final.pdf

*The white paper and report are the result of efforts by The Racing Surfaces Committee that was formed at the inaugural **Welfare and Safety of the Racehorse Summit** in 2006.*

This Racing Surfaces Testing Laboratory Technical Bulletin for Track Surface Education is the first in a series of papers directed toward a general audience with a common interest in developing consistent and reliable track surfaces. This and subsequent bulletins can be found at the Racing Surfaces Testing Laboratory website: racingsurfaces.org/bulletins

shear strength is the resistance of material slipping when loaded with the weight of the horse. Loading that is applied to samples of track material tested in the laboratory match these conditions during use. Test materials are loaded vertically (as with the weight of the horse), and then the resistance of the material to sliding is measured. Failure, or sliding of the material, replicates the slide that can occur in the soil beneath the hoof during the propulsion phase. The test used is called the triaxial shear test.

This test has been the subject of a recently published scientific paper that compared the response of several synthetic racing surfaces at different controlled temperatures in the laboratory (Bridge et. al. 2010). It also allows us to understand the effects moisture has on dirt tracks relative to shear strength. It is not unusual for a dirt surface to decrease its ability to support the propulsion of the horse by as much as 25% when only a 4% change in moisture content is exhibited (see figure 3). In synthetic racing surfaces, this effect is mirrored by a similar change of shear strength due to temperature (figure 4). Currently, no one can say that a particular measurement of shear strength leads to a safer surface. However, it is generally accepted that changes in shear strength due to changes in moisture or temperature should not be abrupt. It is also likely that a dramatic change between surfaces varying in shear strength used by a particular horse should be avoided. As more tracks are characterized, it is likely that trends will emerge so that triaxial shear strength will be one more tool used by racetrack superintendents to maintain a consistent surface and owners, trainers, and jockeys may utilize this information to make better choices for their horses. By controlling moisture and avoiding variation due to heating from the midday sun, a consistent track should be achievable for trainers and to help protect the safety of the horses and riders.

Footnote:

J. W. Bridge, M. L. Peterson, C. W. McIlwraith, and R. M. Beaumont, 2010, "Temperature Effects on Triaxial Shear Strength of Granular Composite Sport Surfaces", Journal of ASTM International, Vol. 7, No. 9 DOI: 10.1520/JAI103139

Racing Surfaces Testing Laboratory encourages the distribution and use of these bulletins. For further information, contact:

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