RACING SURFACES TESTING LABORATORY
Technical Bulletin #1 for Arena Surface Education

Equestrian Surfaces Part I – Sand Specifications

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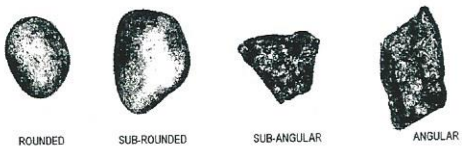


FIGURE 1 Variations in sand shape, a schematic overview of main categories.

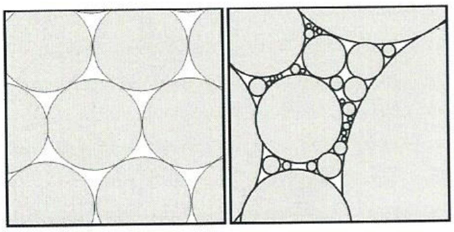
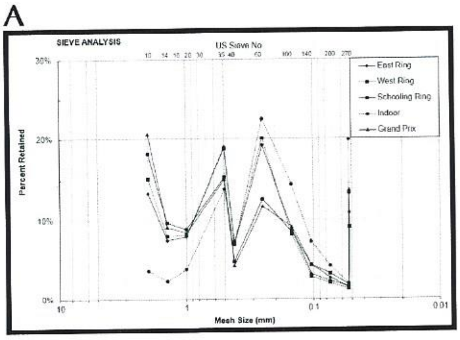


FIGURE 2 Different sand size and distributions lead to variations in pore size.

A



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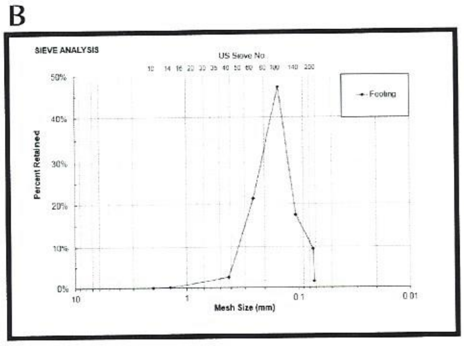

FIGURE 3 Sieve analysis examples.
a) Sand arena surface with poor performance properties. b) Well-functioning sand and artificial fiber arena surface.

Introduction

Sand is the key footing component of most horse-riding arenas. In this respect, fundamental knowledge of sand specifications is essential for a deeper understanding of the mechanical properties of equestrian surfaces. Sand is a complex material comprising variable fractions of sand grains with a distinct mineralogy and pore space filled with air and water. The relative fractions of these components greatly influence the mechanical properties of the arena surface and thus distinguish good from bad arena sands. In this context, sand shape, size, sorting and mineralogy plays an important role.

Sand Shape

Microscope analysis is used to identify sand shape and divide it into four main categories as shown in Figure 1. In a natural environment, sand originates from eroded rocks. Prolonged time spent on transport and tumbling by water during deposition typically forms a sub-rounded to round shape of the grain. Manufactured sand is artificially produced by crushing rocks mechanically into smaller fractions forming more angular grains. The shape of sand grains influences the cushioning of the footing and the resistance of the surface to slip when loaded with the horse's weight (shear strength). Angular grains increase the friction between grains compared to more round ones. This results in increased shear strength but also in increased abrasion on hooves or hoof shoes due to their sharp surfaces. Furthermore, the more angular-shaped the grains are the higher is the tendency to break and introduce fine materials which will cause the surface to compact and create harder footing. Sub-angular particles offer a good solution to prevent rolling effects but promote elasticity.

Sand Sizes

The sand size refers to the diameter of the particle denoted in mm or U.S. sieve size. Sand is larger than clay (diameter ≤0.002 mm) or silt (0.002-0.063 mm), also denoted as "fines", and smaller than gravel (2-63 mm). It is important to note that the crucial parameter of arena sand is the size of the pore space between sand grains, which directly depends on the sand grain size and size distribution (Figure 2). Smaller pores are a result of either having very small grains evenly distributed or of having particles ranging from large to very small grain sizes. The size of pores influences the ability of water to permeate the surface and will also influence the way in which water will hold the grains together. In general, sand with small pore spaces will compact more easily with negative impacts on drainage and elastic properties of the footing. Larger pores formed by large rounded sand grains of the same size lead to a very unstable surface with poor shear strength. Thus, finding a good compromise between too small or too large pore sizes is desirable. Hence, careful consideration not only of sand grain size but also of sand sorting is essential for achieving optimal mechanical properties of the arena footing.

Sand Sorting

A standard method to determine the particle size distribution is the sieve

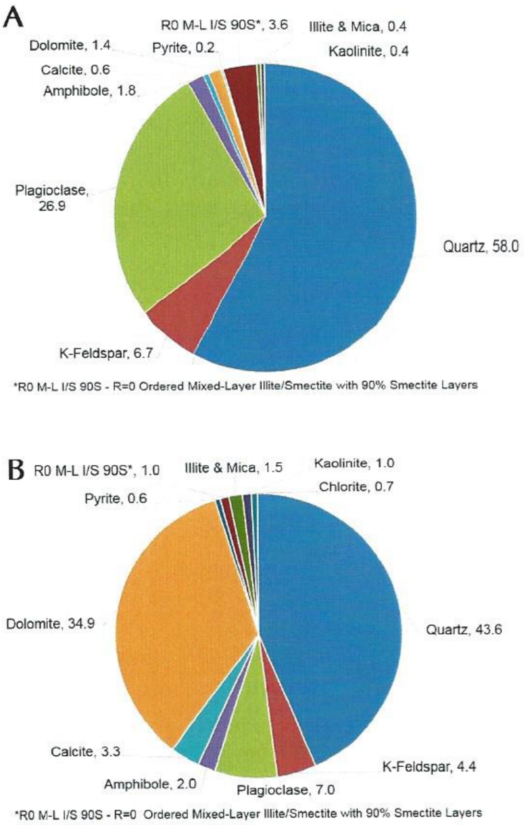

FIGURE 4 X-ray diffraction analysis of sand mineralogy. a) High percentage of hard silica minerals such as quartz, feldspar (including plagioclase), amphibole, and phyllosilicates (clay) creates durable sand. b) Less durable sand is formed by grains with a high proportion of soft carbonate minerals such as calcite and dolomite.

This technical bulletin is part of a series of papers directed toward a general audience with a common interest in developing consistent and reliable surfaces for equestrian sports. You can find more information on the subject in the Equine Surfaces White Paper and in Equestrian surfaces –a guide. Both documents are published by the Fédération Equestre Internationale (FEI) available on the FEI Website http://www.fei.org/fei/about-fei/publications/fei-books

These documents are a collaboration between experts from the UK, the United States, Sweden, Canada and Germany representing six universities, three equine research and centers, and sport representatives. The latest data and published scientific papers on arena and turf surfaces, and the effects on horses in training and in competition are summarized for a general audience.

separation test using a series of sieves as described in standard test methods (ASTM 2007). The mass of sand in each sieve is recorded at each step until the remaining particles in the lowermost catch pan (< 0.0037 mm) are assumed to be fine silt and clay sized particles. These parts can be further analyzed using the wet sieve test, hydrometer test, or x-ray diffraction method discussed in technical bulletin #1 for track surface education. Results of the sieve separation test are commonly presented as a chart showing the percentage distribution of the material that has passed through the sieves as a function of the respective sieve size (Figure 3). Footings with sand particles that are all nearly the same size resist compaction but may have insufficient grip and the tendency to feel deep. In contrast, sandy materials with a broader grain size distribution which may include a larger proportion of very fine silt or clay will have high shear strength but will compact, leading to a hard surface with poor drainage properties.

Most sand arenas use sand size distributions with no more than 2 peaks in the range of sieve #10, 35, 60 and 100 (Figure 3a). To achieve both, low compaction and high shear strength, artificial fibers can be used. Fiber allows the arena to have higher shear strength by increasing the binding between sand particles while maintaining open pores. Arenas which use fine and coarse fibers (usually around 2.5 % mass percentage) and a very small amount of fine material (clay <2 %, silt <6 %) can both minimize compaction and minimize dust. A typical sieve analysis chart of such an arena shows only one peak of sand distribution in the range of 0.06-0.2 mm, sieve #70-230. Figure 3b shows an example of a very well-functioning dressage arena footing with a peak at 0.15 mm, sieve #100.

Sand Mineralogy

Sand originally derives from rocks with certain mineralogy depending on the regional geology. The mineralogical composition of sand can be analyzed by x-ray diffraction (Figure 4). According to the hardness of the source mineral, wearing from maintenance and horse traffic can either break large grain particles into smaller angular particles or grind angular into rounded grains. These effects lead to an increased production of smaller sized particles that tend to compact and harden the surface. A high portion of quartz (SiO2) forming hard silica sand makes the surface more resistant to wear. Hence, many well respected arenas use a high amount of sub-rounded silica sand (up to 98 %) which is very consistent in size. This is then mixed with fiber to produce a surface with adequate shear strength and a low risk of compaction.

Conclusion

Choosing the "right" sand for an optimal arena is not straight-forward. This is not only because the type of available sand is limited to what is regionally supplied. An additional important role is played by the arenas design and purpose as well as the types of additives used in the footing. Moreover, the maintenance of the footing is key. This intricate matter is the subject of an upcoming consecutive series of publications in these technical bulletins.

ASTM, 2007, Standard Test Method for Particle-Size Analysis of Soils, ASTM Standard D422 – 63, West Conshohocken, PA.

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

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