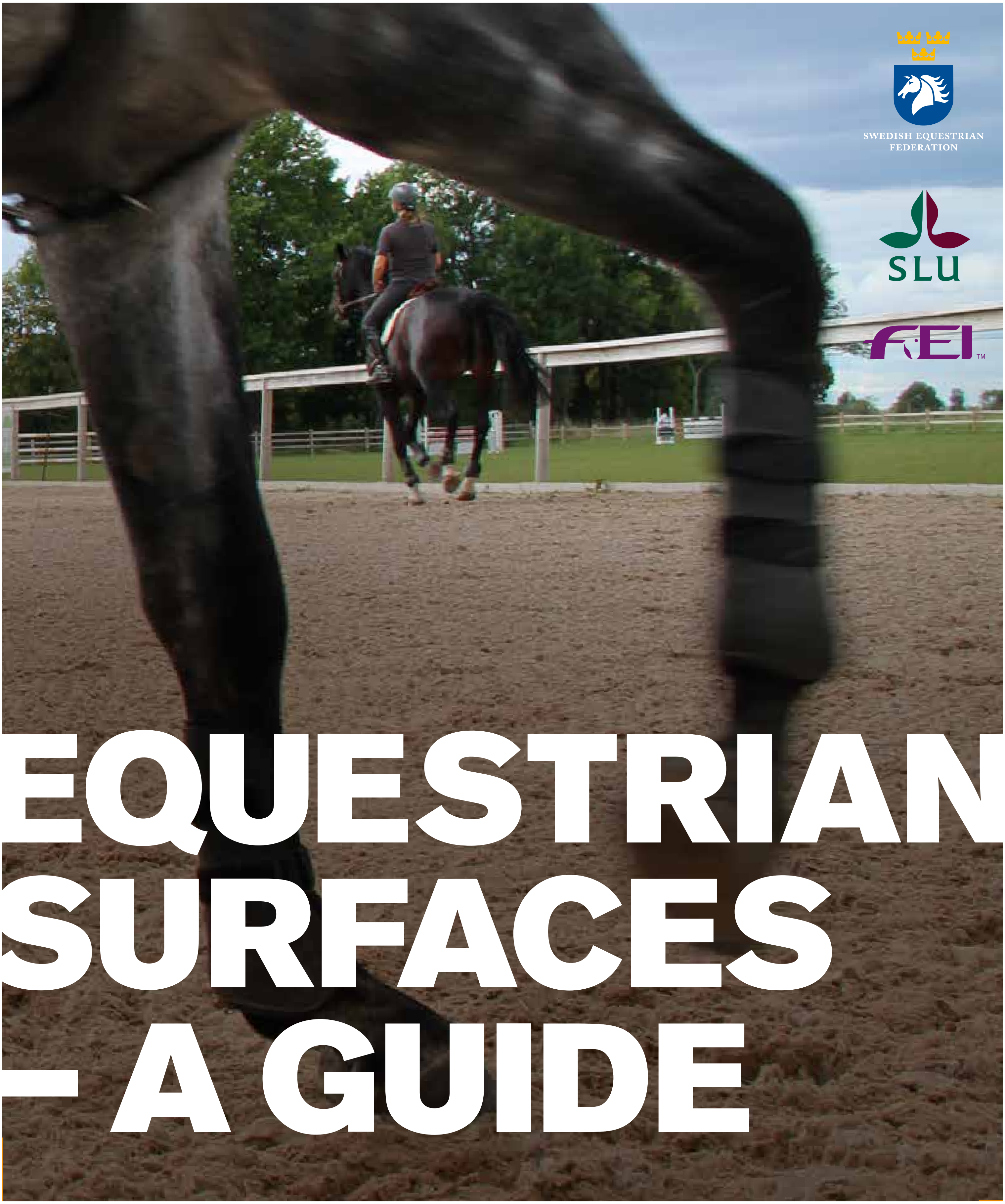

SWEDISH EQUESTRIAN FEDERATION

SLU

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EQUESTRIAN SURFACES – A GUIDE

FOREWORD

The Swedish University of Agricultural Sciences (SLU) pioneered modern research on functional properties of equine surfaces in the 1960s. The work of Professors Fredricson and Drevemo and their group led to trotting racetracks being banked.

Since then a large number of scientific papers have been published in the academic press by research groups from, for example, United States, United Kingdom, France, Japan and Sweden. A vast majority of these papers have been aimed at racetrack properties and their effect on the horse locomotion.

In 2007-2008 SLU initiated a project financed by the Fédération Equestre Internationale (FEI), World Horse Welfare and Swedish Foundation for Equine Research that was specifically aimed at equestrian arenas. It was titled ”Evaluation” of training and competition surfaces in equestrian sport, and the consequences for improved welfare and orthopaedic health of horses that use them”. The project combined epidemiological field studies of Jumping yards and arena testing and rider evaluation in Sweden, the Netherlands, Switzerland and the UK.

During this project, contact was established with Professor Michael Peterson in Maine (US) who had constructed a mechanical hoof, which was successfully used to test thoroughbred racetracks. The mechanical hoof was jointly adapted to better suit testing of equestrian arenas and a successful collaboration was formed with Dr. Rachel Murray's group at the Animal Health Trust and later on also Dr. Sarah Jane Hobbs at University of Central Lancashire and her collaborators at Anglia Ruskin University and Myerscough College.

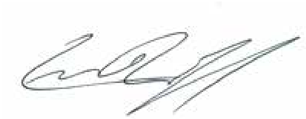
An important outcome of this collaboration was the "White paper on equestrian surfaces", which was produced with Sarah Jane as first author and which has been published by the FEI. Please have a look to see a list of all contributors and find more in depth information and references related to the present document.

In 2013, the FEI financed another research project with the aim of defining the relationship between subjective evaluation of arena properties and measurable parameters, as well as acceptable upper and lower limits for these parameters at major events. It was concluded that the subjective judgment of riders matches the objective measurements and this enables recommendations on a range of these measurements satisfying rider expectations for competition surfaces. This is something we will write more in detail about in coming editions of this publication.

During 2014, the Swedish Equestrian Federation sponsored and co-produced the Swedish version of the publication that you now hold in your hand. The majority of writing and compiling text was done by Doctors Cecilia Lönnell and Elin Hernlund. Thanks!

The FEI decided to finance a translation to English. Dr Cecilia Lönnell translated the text and the rest of the team – pictured below – did a thorough job with scientific scrutiny and editing. Many thanks to them all!

I am happy to be part of this joint effort that I expect will continue to develop knowledge around Equine surfaces and their influence on horse performance and soundness.



Professor Lars Roepstorff, Swedish University of Agricultural Sciences

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Ph.D. Student at the Swedish University of Agricultural Sciences (SLU), within the FEI/WHW research project on Jumping training, injury and surface use. Research interest also horse-rider interaction and objective lameness tools. Equine clinician in the University Animal Hospital.

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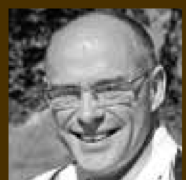
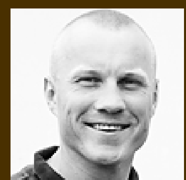
Text, including popular science adaptation and research.

Ph.D. Research on equine training and injury at the Royal Veterinary College in England and at SLU, including in the FEI/WHW research project on showjumping training, injury and surface use. Veterinarian, equestrian journalist (six Olympics).



Lars Roepstorff, Sweden

Ph.D. Professor in Equine Functional Anatomy at the Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden. Research focused at equine surface properties, horse-rider interaction and objective lameness tools, all to promote health and performance. Veterinarian. Rider at advanced level Jumping.



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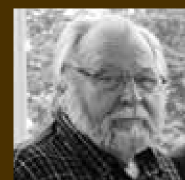
Project manager. B.Sc. in Equine Science, former stable manager at Flyinge (National) Stud. Now at the Swedish Equestrian Federation department for Riding schools and Equestrian Centres, responsible for equine management.

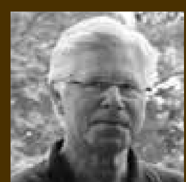


Lars Bergström, Sweden

Engineer, fourth generation horseowner. Surface material expert with long experience of installing both trotting track and riding arenas in Sweden.

Ann-Margrethe Andersson, Sweden

Swedish Fellow (Level IV riding teacher qualification), former riding school manager, competed S-level Dressage. Trainer of riders and horses.



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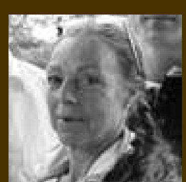
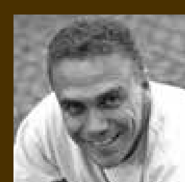


Fia Krügel, Sweden

Riding teacher and former riding school manager with many years of experience. Children successful eventers at YR-level.

Markku Söderberg, Sweden

President of the Swedish Equestrian Federation section for Riding schools and Equestrian Centres. Riding school manager, Jumping rider and coach.



Oliver Hoberg, Germany

Expert in installation of competition surfaces both indoor and outdoor, including at Olympic level, acknowledged by the Federation Equestre Internationale.

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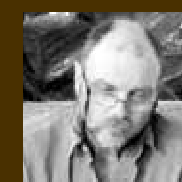
Ph.D. Libra Foundation Professor of Engineering, University of Maine, United States. Research links traditional understanding of engineering mechanics and materials to the biomechanics of animals. Developed the Orono Biomechanical Surface Tester. Co-founder and Executive Director of the Racing Surfaces Testing Laboratory.



Jeff Thomason, Canada

Ph.D. Professor of Biomedical Sciences, Ontario Veterinary College, University of Guelph, Canada. Internationally-recognised for his research on the form and function of the equine hoof, co-author of racing surfaces White Paper.

Carolyne Tranquille, UK

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Vicky Walker, UK

B.Sc., M.Sc. Equine Orthopaedic Research Assistant at the Animal Health Trust, UK. Main focus of research is gait analysis of sport horses.

INTRODUCTION AND READING SUGGESTIONS

This document has been produced by the Swedish Equestrian Federation's reference group for riding surfaces. The reference group and its advisors include representatives of equestrian sport, riding schools and the Equestrian Federation, equine veterinary scientists from the Swedish University of Agricultural Sciences, and specialists with extensive practical experience of riding arena construction.

Traditionally, advice on the construction of riding arena surfaces have been based on experience and personal opinion, which can be subjective and lacking scientific rigour. In recent years this has changed, as research methods and equipment have been developed by scientists. This has allowed testing and analysis of riding surface properties, and their effects on the horse to be quantified. While this scientific work is still ongoing, the aim of the guide is to share current scientific data that applies to equestrian surfaces, in combination with practical know-how from experienced arena specialists.

The English version was reviewed by an international panel of leading biomechanics and equine surface researchers from the United States and the United Kingdom.

The guide can be read from beginning to end by the ambitious reader, but we offer the following suggestions regarding the most relevant chapters for your specific role and interests:

Are you a rider, coach, riding teacher, or otherwise active in equestrian sport, and want to increase your knowledge about, and understanding of, riding surfaces?

We suggest you read the introduction, then the chapters on training, the interaction between the hoof and the surface, surface properties and materials, multipurpose arenas and competition, maintenance and arena testing.

Do you run an equestrian business, represent a riding school or plan to build or renovate your own riding arena?

We suggest you read the introduction, then the chapters on training, the interaction between the hoof and the surface, surface properties and materials, budgeting, environmental considerations, the building process, multipurpose arenas and competition, maintenance and preferably also arena testing.

Are you an entrepreneur owning a quarry/sandpit/building business with customers in equestrian sport and want to improve your knowledge about riding surfaces?

We suggest you read the introduction, the interaction between the hoof and the surface, surface properties and materials, environmental considerations, the building process, multipurpose arenas and competition, maintenance and preferably also arena testing.

This first edition of the guide focuses on sand-based outdoor and indoor arena surfaces, but discusses principles that also apply to any riding surface such as grass or roads.

THANK YOU!

The Swedish Equestrian Federation reference group expresses sincere thanks to its advisors Karsten Koch, Germany, for important advice on arena materials and maintenance (see own presentation and photo) Architect Mats Molén and Michael Ventorp at the Swedish University of Agricultural Sciences (SLU) who gave important input especially on the building process chapter.

▲ *Karsten Koch is a riding surface consultant with 25 years of experience. Like Oliver Hoberg he worked with the late surface expert Hermann Duckek. He has collaborated with Oliver Hoberg since 1994, including at international shows. Among his consultancy clients are riding schools.*

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Equestrian surfaces – a guide is a joint venture between the Swedish Equestrian Federation and the Swedish University of Agricultural Sciences.

Design: dizain.se **Cover:** Jessica Ortiz Bergström
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Photo: Jessica Ortiz Bergström

1 INTRODUCTION

Know-how is important in order to install a good riding arena surface. Today, findings from scientific research into equine surfaces can be combined with specialists' practical experience to produce a good surface. But there is no single recipe for a riding arena.

◀ The surface for the equestrian Olympics arena at Greenwich, London in 2012 was developed with the aid of mechanical surface testing described in this guide, and conducted by scientist members of the reference and review groups listed on page 4 and 5. A unique feature of this surface was the fact that it was not laid on the ground but on a platform (see inset) above it. This also posed a main challenge regarding the arena properties.

Equestrian arena surfaces are a major investment for stable owners, riding clubs and private horse owners. With the growth of equestrian sport in recent decades, both in terms of financial turnover and number of participants, demands on and expectations on equestrian surfaces have increased. Surfaces are expected to promote both performance and soundness.

Scientific testing of equine surfaces was first developed within Thoroughbred and Standardbred racing, where for decades scientists have studied associations between orthopaedic injury and surface properties. The background of biomechanical research into equine surfaces is described in more detail in the foreword. Thanks to these studies the information in this guide is supported by scientific data and on-going research.

The guide also utilises advice from international arena consultants and equestrian professionals with years of practical experience of building and maintaining surfaces.

The guide is aimed at those who want to build or renovate a riding arena, or those who require more knowledge about riding surfaces. Furthermore the guide provides advice on building and maintaining an indoor or outdoor arena.

Many equestrians discuss and want an answer to what is ”the best” riding surface. As this guide shows, it is wiser to talk about a ‘surface that is most suited to your and your horse’s needs’, and that how well it works will also depend on how you treat it.

Firstly, it is important to understand the difference between surface materials and surface properties. The properties of any surface material can differ from day to day, depending on use, maintenance and environmental factors. The current properties of the surface and the immediate decisions the rider makes for that training session directly affect the horse. Different materials and construction principles can be used to provide surfaces with the same properties, but day-to-day maintenance strategies will also play a role in the properties of the surface.

Several factors should be used to decide on the type of construction and the materials you select for your arena. These include the needs of the yard/stable, your current financial resources for the initial construction and your long-term resources for maintenance, the local climate and soil type. The basic ingredient in arena surfaces are usually sand, although in some countries other material, such as rubber or woodchips, is the only top layer ingredient. When using sand, the type of sand that is readily available varies greatly between and even within countries, depending on source. Consequently, you will not find one single "prescription" or "recipe". This guide instead gives suggestions and guidelines for different solutions. The chapter on the building process provides advice on choosing a building contractor or "Do it yourself".

Another important point when installing a riding surface is to keep a broader perspective in relation to environmental considerations and the importance of continuous, appropriate maintenance. Moisture content, for example, is a key environmental factor that will affect surface properties.

An electronic version of this document is available and will be updated annually to incorporate new scientific findings.

GUIDE TAKE HOME MESSAGE

- Similar surface properties can be obtained with different material
- It is the properties of a surface rather than the material it is composed of that affect the horse
- The properties of the same arena will change based on wear (use), maintenance and environmental factors
- The risk of injury on a surface is to a large extent determined by how it is used. This means that riding intensity, speed, duration and frequency as well as the type of work you do on a surface are as important as the properties
- Variation of surface use and a gradual introduction to different surfaces should be an important factor in a horse's training plan
- As a private individual customer it is difficult to get sufficient data on sand for riding arenas. A sieve analysis of the sand is a start but is not enough. Obtain help and advice from an appropriate expert, or alternatively get an analysis of the sand in an arena you know works well
- A riding surface is only as good as the maintenance programme
- Water (moisture) is one of the most important factors for influencing properties of a surface

2

TRAINING FOR SOUNDNESS AND PERFORMANCE

Soundness and performance are often cited as the motivation for constructing, maintaining and using a riding surface. In this context it is very important to be aware that the single most important factor for both soundness and performance is how the horse is trained and managed.

Photo: Mikael Sjöberg

THE CHAPTER IN BRIEF

Soundness and performance are the main focus in most discussions of riding surfaces. Lameness and back pain are the most common problems requiring veterinary care and leading to loss of use in equestrian sport. Whether a horse is sound of course depends on an intricate combination of internal (often inborn) factors such as breeding, conformation, age, training history and previous injury plus external factors such as training and surface use. When it comes to soundness external risk factors are much easier to influence than internal risk factors.

In common with humans and other animals horses benefit from exercise and natural movement. Lack of work can be a bigger health risk than exercise and training, but training can also increase the risk of injury. If the horse is expected to perform without an adequate work up or to do repetitive work over long time periods, then habitual movements can have degenerative effects just as they do in human athletes and in the workplace.

Scientific research on race and sport horse orthopaedic injuries has found that the risk of injury differs between yards/riders/trainers. Studies have also shown that training and surface use interact to influence injury risk.

Four important principles to follow in planning a horse's work:

1. Gradual increase of training and fitness
2. Variation in the type of work
3. Skill-specific training
4. Individual adjustments

Description of a training session (or plan) should include definitions of:

- Type of activity
- Duration (time and/or distance)
- Intensity (level of exertion)

We want to begin this guide with an overview of training principles and their association with soundness and performance.

We have already mentioned some essential training principles that are important to keep in mind in view of performance and soundness. They are as relevant for a horse as for a human who is actively engaged in a sport or physical work.

"The most important principle in training is that the work must be increased gradually"

This is a statement from Professor Gerhard Forsell, the Swedish team vet at the 1912 Olympics in Stockholm and later regarded as a veterinary legend, in his 1927 book "About the Horse, Its Anatomical Conformation, Management and Diseases", which was produced as a handbook for a Federation rider badge.

How the quality of riding in itself influences equine soundness is a fairly new area of research. But a study of riding school horses by the surface research group at SLU showed that riding schools with a low incidence of orthopaedic injury more often had highly trained riding teachers and experienced riding school managers.

FACTORS THAT INFLUENCE EQUINE SOUNDNESS AND PERFORMANCE

Graph: Lars Roepstorff and Linda Eriksson

The soundness and performance of a horse is influenced by complicated associations of many factors, where riding surface and training both play an important part.

BASIC PRINCIPLES OF TRAINING

Gradual increase of training and fitness

One obvious principle for most people who have had any experience of physical training is that muscle adapts and is "rebuilt" in response to training, getting larger and stronger depending on the type of exercise. This requires a gradual progression over time, or the muscle risks being overloaded and injured. Building fitness also requires a gradual process. Fitness is the body's capacity to use oxygen, involving the lungs, heart, blood and muscle, which can all be trained. It is important to understand that the musculoskeletal system also includes bone, cartilage, tendons and ligaments that adapt to training and work. Bone increases in density and strength, cartilage increases in thickness and fluidity, and tendons and ligaments benefit from improved coordination and proprioception. Bone, cartilage and tendons/ligaments take much longer than the lungs or muscles, to adapt to new activity, or an increase in intensity/volume, which if ignored can lead to an increase in injury risk.

A key factor in training for both soundness and performance is therefore to increase the workload gradually with respect to type, volume, intensity and recovery. As in all sports it is especially important that the young or previously untrained individual is allowed to build physical strength through well planned basic training, before making more specific demands, for example, Jumping or Dressage. The same principle holds for rehabilitation after an injury.

◀ *Continuity of training is an important factor in training if it is going to have the desired effect. Lack of continuity can increase injury risk. Paddock time in a small area has no physical training effect.*

Variation

Continuity is an important aspect of training if it is going to have any lasting effect. One or two sessions at the gym makes little difference for a person, or can even increase injury risk. The same goes for horses; without regular repetition any training effect or improvement in fitness will be minimal.

At the same time it is important to include variation, based on training activity, volume and intensity plus rest and recovery. The variation is aimed at increasing the total training effect and decreasing the injury risk, both long and short term. If the horse's daily training is carried out at low intensity, injury risk will increase on occasions when the horse is subjected to higher loads as fatigue is a known risk factor for injury. Muscles play a role in absorbing the work load, and when the horse tires the load on tendons, ligaments and cartilage increases. It is therefore important to include fitness training to improve the horse's physical endurance but again there should be a gradual increase in demands. Attempts to go "fast forward" in training can result in fatigue and subsequent injury.

One method to increase the training effect in a controlled manner is interval training. This means that the horse performs repeated bouts of work separated by rest intervals- that allow partial recovery. The intensity and length of the exercise bouts will be tailored to what the horse is being trained for.

Training variation promotes general strength and endurance, which in turn can be expected to promote long-term soundness. Training variation helps balance the need for "rebuilding" or adaptation, which is an important part of the effect of training.

Based on experience, training variation also helps promote mental motivation in both the horse and human athlete.

Human sports research has shown that balance and coordination are important factors in injury prevention. A horse who is only ridden in an outdoor or indoor arena will have very limited chances to develop balance and coordination, compared to a horse that is also hacked out on different types of terrain. The quality of riding can also be expected to influence the extent to which the horse is able to move in balance.

◀ *Dressage horses need very specific training to perform advanced moments. At the same time it is important not to forget other aspects of training that strengthen the horse's fitness and supportive tissues.*

Specific training

Once the basic training and conditioning is done the horse needs to adapt gradually to the type and amount of work that will be expected in competition or other full work. This requires specific training of technical skills, such as motor and mental control, through Jumping exercises or Dressage movements depending on the main discipline of the horse. Specific training may also involve communication with the rider or developing specific strength, speed or endurance.

Any changes in training or work load must happen gradually, also when changing riders or discipline. A Dressage or Jumping horse being prepared for Eventing requires adequate time to be prepared for the new discipline.

An advantage of specific training is that it makes it easier to balance the volume and intensity of work so that you get a training effect with less risk of overloading. One obvious human example of specific training is strength training in a gym. If we can develop exercises for our horses on similar lines, this would help to make training more efficient and safer.

Individual training

There is no universal recipe for successful training that works for all horses. Horses are individuals with different temperaments, conformation and movement, which must be taken into account in all training. Individual training also means that you monitor how each horse responds, making modifications if the effects are negative or in other ways unwanted. If the horse shows signs of fatigue then the trainer must make short-term changes and, if these are unsuccessful, then long-term changes are required. Individual training is, to a major extent, a question of learning to "read" each horse.

SURFACE, TRAINING AND INJURY RISK

When discussing surfaces in relation to performance and reducing injury risk it is important to remember that the way you use a surface is as important as which surface you use and its properties.

Training variation means riding on a variety of surfaces! This includes using more than one arena, but especially riding on varied natural terrain, (quiet) roads and riding paths. The body of the horse adapts to the surface used. If the horse is constantly ridden on the same surface the musculoskeletal system is not prepared for any variations, thereby increasing the risk of injury.

Surfaces can also be used as a part of a training regimen aimed at promoting soundness. British riders have a tradition of roadwork, with gradually increased distances of walk and trot on roads/tarmac. There is one school of thought that road work strengthens the musculoskeletal system, while based on other traditional experience it is part of a gradual conditioning programme to develop a better conditioned horse that will have less risk of fatigue and thus less risk of injury.

Surface properties can affect both performance and the risk of injury. One dilemma is that properties that aid “better performance” also increase the load on the horse’s musculoskeletal system and can increase injury risk. One example is a surface which is very firm/hard and/or excessively “grippy”, making it is easier for the rider to ride fast and turn quickly. Higher speed in itself also increases the load on the horse’s leg.

If the horse competes on a surface with certain properties, the training preparation should include exercising on the same type of surface to allow for adaptation. If you are going to compete on grass, it is preferable for the horse to also train on grass. Prior training on surfaces that the horse will use at competition should allow the horse to experience the surface properties at a reduced work intensity, rather than having to do this while also being asked to perform to its optimum level during competition. Adaptation has several aspects, one of which is that the horse’s pattern of movement is changed and probably adjusted to different surfaces. An example is the observation that horses not used to working on fibre sand tend to trip in the beginning until they get used to it. Adaptation is also a question of rebuilding the musculoskeletal system in line with the demands. This can take weeks or even months.

WHAT DOES RESEARCH SAY?
Professor Agneta Egenvall at SLU has led a field study registering the training and health of Jumping horses over a period of about six months. Results showed an association between the number of days lost to training due to injury, training factors and surface use.

CLICK AND READ MORE

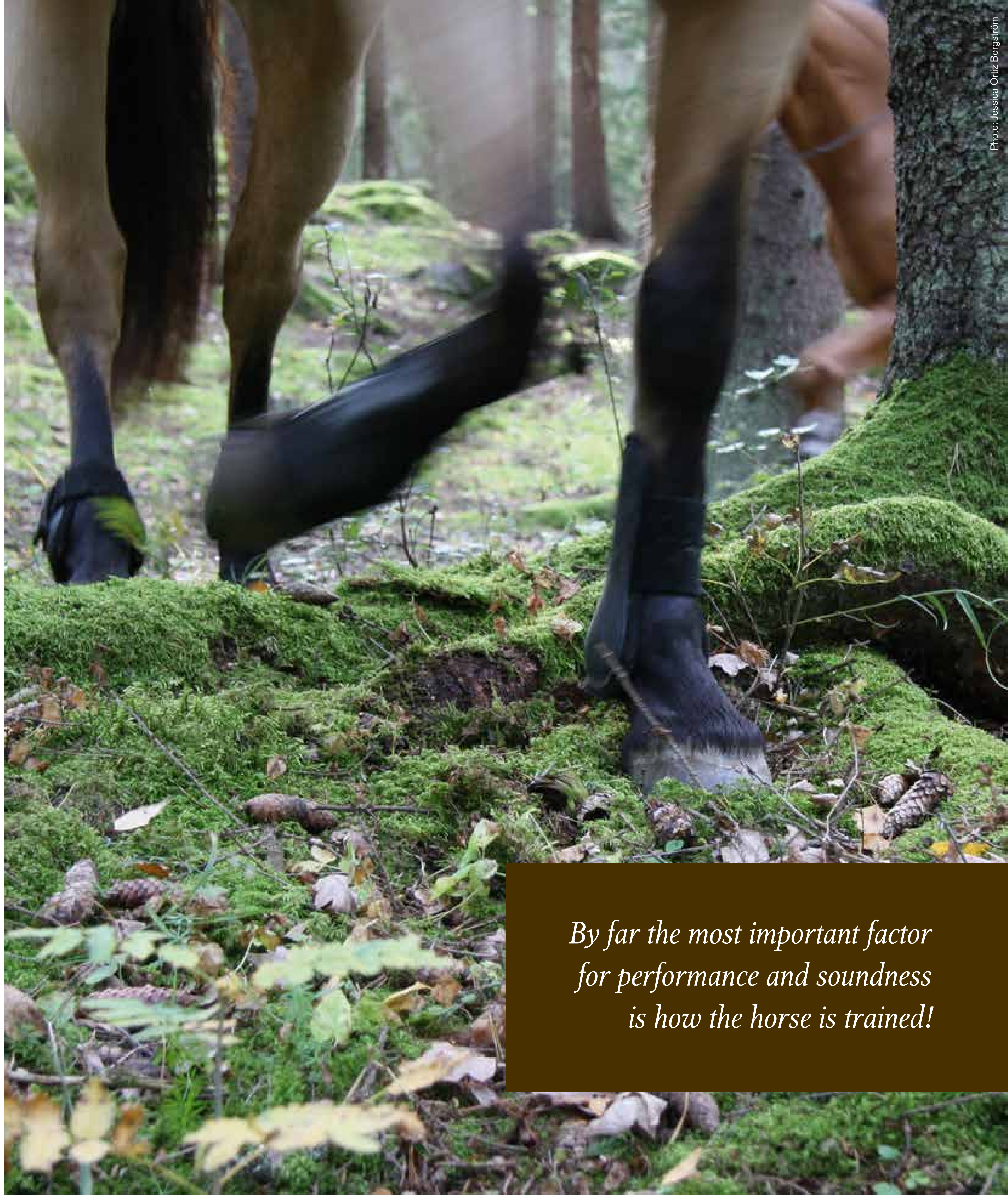


Photo: Jessica Ortiz Bergström

By far the most important factor for performance and soundness is how the horse is trained!

Photo: Svenska Ridsportförbundet

3 THE INTERACTION BETWEEN THE HOOF AND THE SURFACE

The leg and hoof of the horse have withstand great forces when the hoof hits the ground, when it carries the full weight of the horse, as well as well as during turns and when increasing or decreasing speed. Several factors influence the force and load on the leg; the properties of the surface, shoeing, the conformation of the horse, gait, speed and direction.

THE CHAPTER IN BRIEF

At high speed the hoof is only on the ground for a fraction of a second in each stride, but in this brief moment three phases occur, that will affect the horse in very different ways.

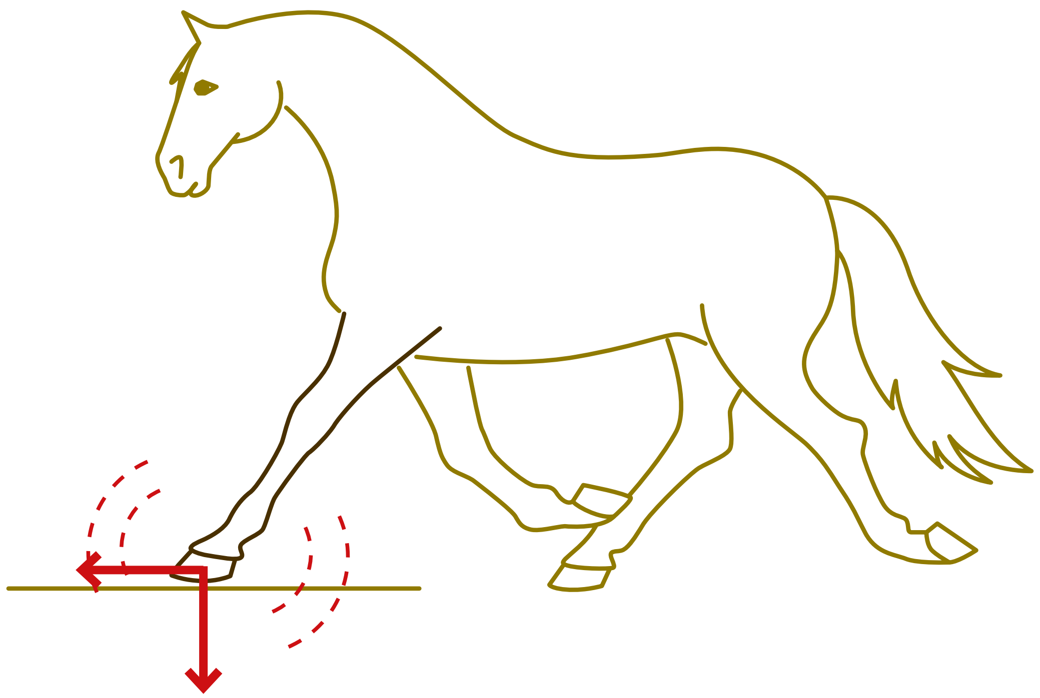
The forces acting on the leg when the hoof is on the ground will have different directions and magnitude. These effects will also depend on the surface properties (for example, whether the surface is hard or soft), the conformation of the horse and how the horse has been shod etc. The phases are:

- HOOF LANDING/TOUCHDOWN – the hoof hits the ground and brakes/slides to a stop.
- SUPPORT PHASE/FULL CONTACT AND LOAD – the whole hoof is in contact with the ground and carries the weight of the horse, (and the equivalent of more at speed – up to two and a half times the horse's weight at full gallop and likely considerably higher when landing after a high fence).
- ROLLOVER/TAKEOFF – Propulsion into the next stride, when the hoof leaves the ground starting with the heels, and "rolls" over the toe.

A stride is defined from the time when the hoof touches the ground until the next time it touches the ground in the subsequent stride. The stride is divided into 1) the support phase, when the hoof is in contact with the ground and 2) the swing phase, when the hoof is in the air. The support phase can be subdivided into three parts that are relevant to the discussion of surfaces and their effects on the horse. The three parts are described in detail below.

Over millions of years, the horse has evolved into having a large body with strong muscles but slim legs and a small, light hoof. This is a requisite for energy efficient, fast running. The modern horse runs on the equivalent of a human middle finger or middle toe. The hoof corresponds to a well-developed nail. When a horse is running fast the braking effect that occurs when the hoof hits the ground is very pronounced. The result is high forces acting on the leg. If the hoof was heavier the forces when the hoof hits the ground would be too high for the leg to withstand.

The phases of the support phase:



HOOF LANDING AND BRAKING (TOUCHDOWN)

First only the hoof first touches the ground, with no influence of the body weight. The body then "sinks" closer to the ground as segment after segment (the bones) of the horse's leg "collide" with each other, rather like a pileup on a road.

The hoof landing means a rapid braking effect during which the hoof slides forward and downward into the surface. The impact and braking forces transmit shockwaves and vibrations through the hoof, joints and bones in lower part of the leg. The harder the surface and the more grip it has, the more shockwaves and vibrations the leg experiences. The hoof is pushed forward into the surface from above, while the top layer of the surface provides traction.

NOTE: Injury risks in this phase mainly affect the hoof and the distal part of the leg. The greater the braking effect on the hoof from a surface that have a high degree of "grip", the greater the forces acting on the leg. On a surface with less grip the hoof will slides further and this helps absorb some of the force. Therefore there should be a certain "slide" in the surface to avoid heavy loads on the lower part of the leg.

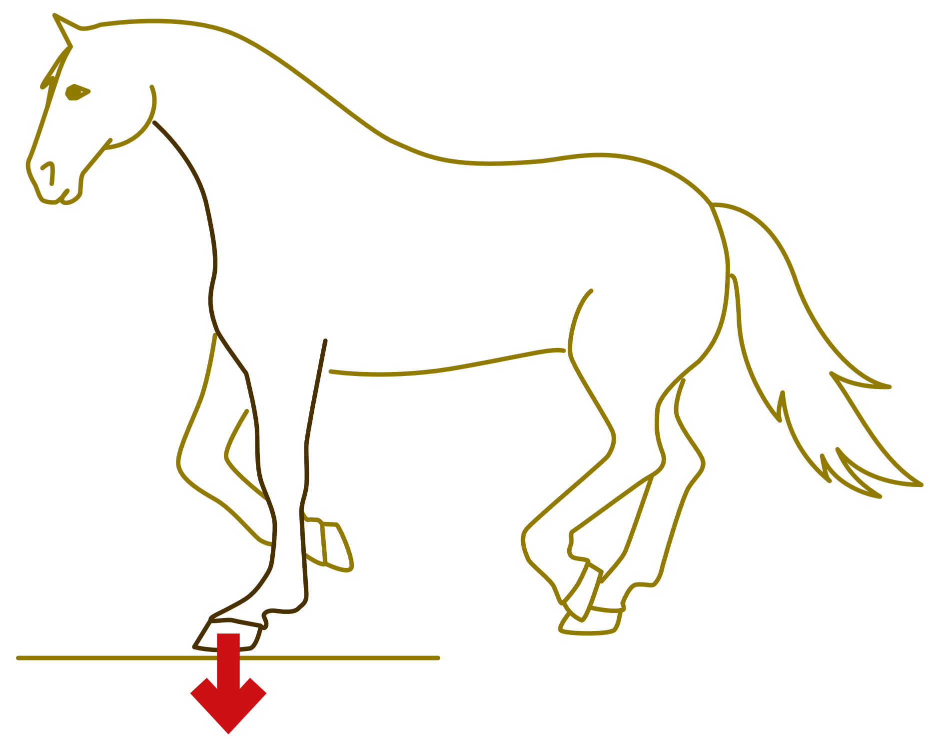
Drawing: Elin Hernlund and Linda Eriksson

SUPPORT PHASE (FULL CONTACT AND LOAD)

The support phase begins when the hoof stops sliding/braking and is in full contact with the ground. The hoof and leg are loaded from above by the full weight of the horse. The fetlock joint sinks towards the ground and the flexor tendons and suspensory apparatus are stretched. This gives the leg a shock absorbing and elastic effect, which is an important contributor to the horse's running ability.

NOTE: The injury risk in this phase mainly affects the tendons, ligaments, joints and bone, due to the large forces they experience.

Drawing: Elin Hernlund and Linda Eriksson

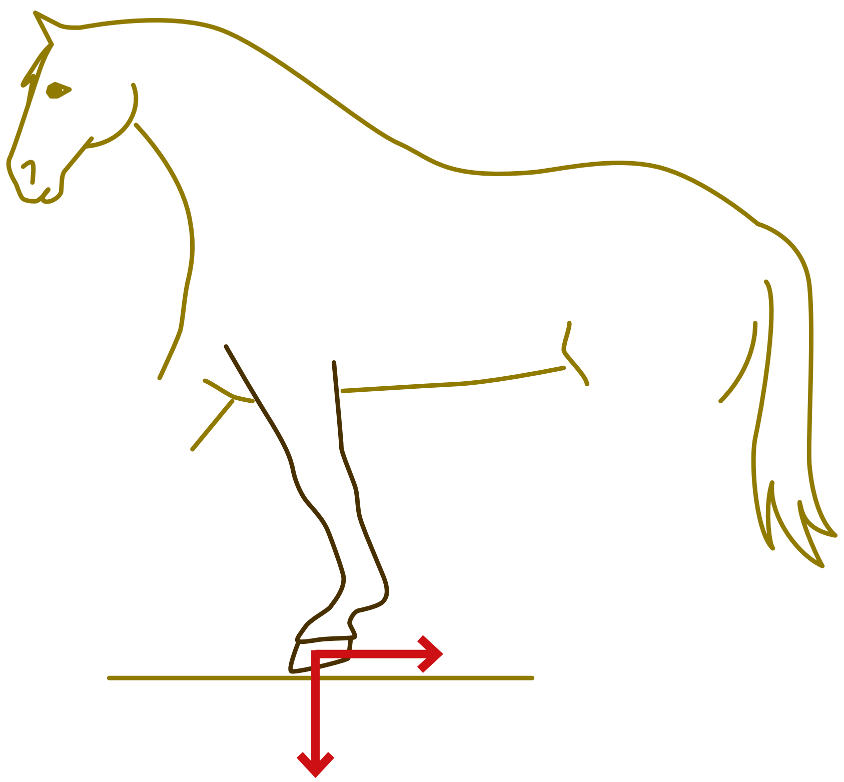


ROLLOVER (TAKEOFF)

At the end of the support phase the horse in effect braces the hoof against the ground, propelling the leg forward. At that moment surface grip (friction and shear strength) is important for the hoof to get sufficient traction. This final phase before the hoof leaves the ground is called rollover (or breakover). The hoof lifts at the heels first and ”rolls over” the toe.

NOTE: This phase loads the ligaments, the hoof wall and the tip of the coffin bone and there is a final marked stretch of the superficial digital flexor tendon. The result is that the hoof and leg swing forward in a semi-automatic way.

Drawing: Elin Hernlund and Linda Eriksson



The maximum load on a front leg during the support phase at a gallop has been estimated at 2.5 times the horse’s body weight. This corresponds to 15 kilo newton (equivalent to 1500 kilograms of weight).

IN DEPTH

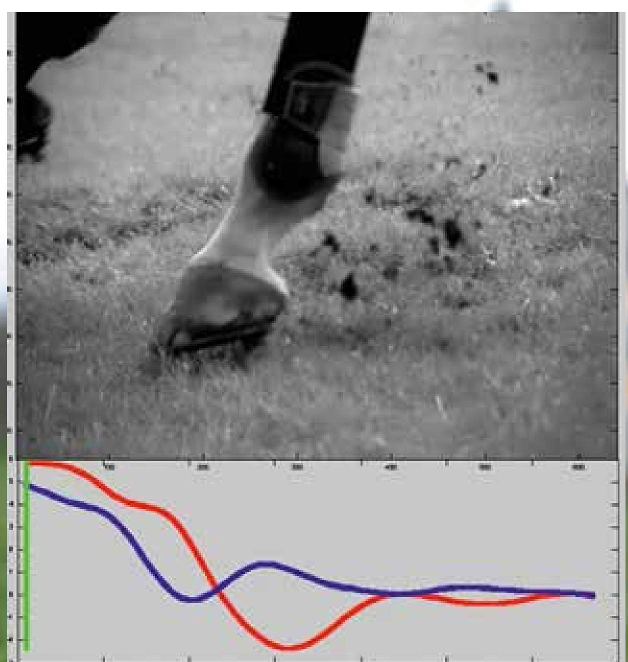
On the next pages you can view in detail what happens when a hoof lands on different surfaces. The movie clips are filmed with a high speed camera capturing 1000 frames per second. The red line shows horizontal (forward) speed and the blue line shows vertical (downward) speed. The green line show dynamically the time in data series corresponding to the video frame shown.

The film material is part of a research project on arena surfaces for Jumping horses conducted by the equine surfaces group at the Swedish University of Agricultural Sciences (SLU).

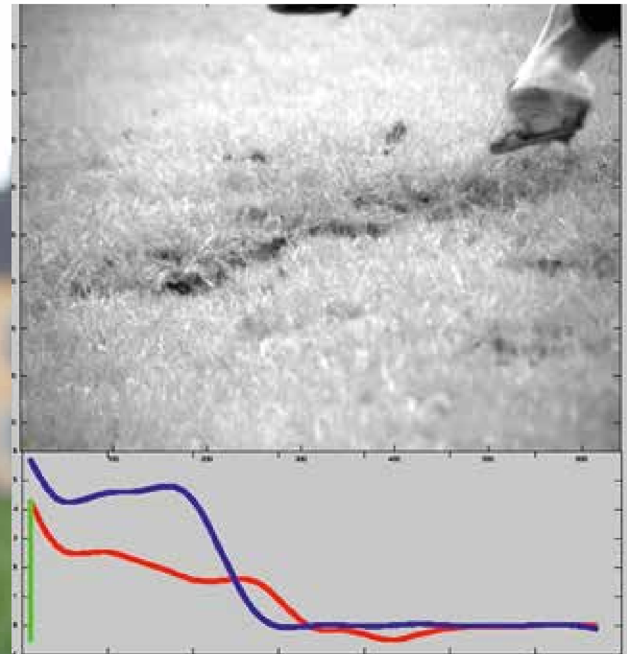
CLICK AND READ MORE
Here is the scientific article published based on the high speed hoof landing films.

Hoof landing on a grass surface

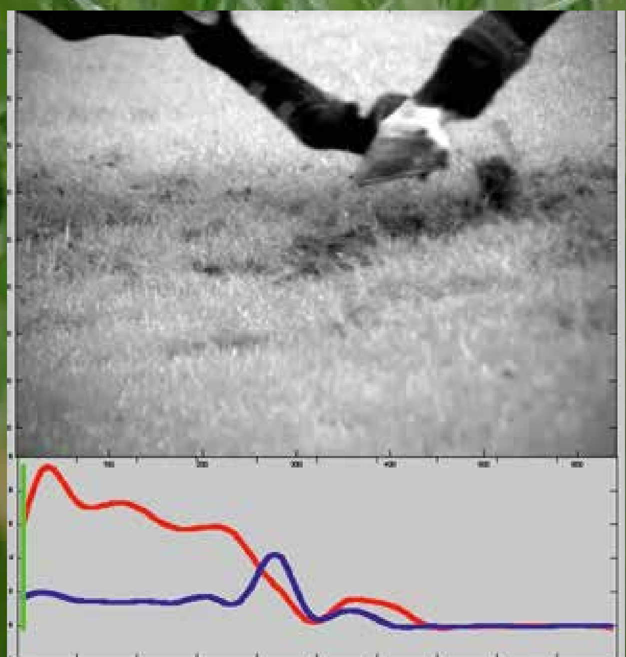
Films: Elin Hernlund Graphs: Lars Roepstorff



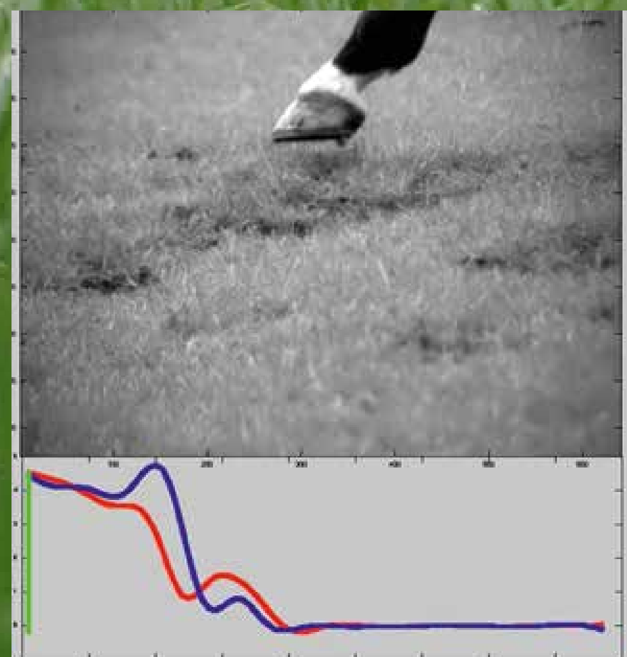
GRASS OUTER HIND LEG



GRASS OUTER FORE LEG



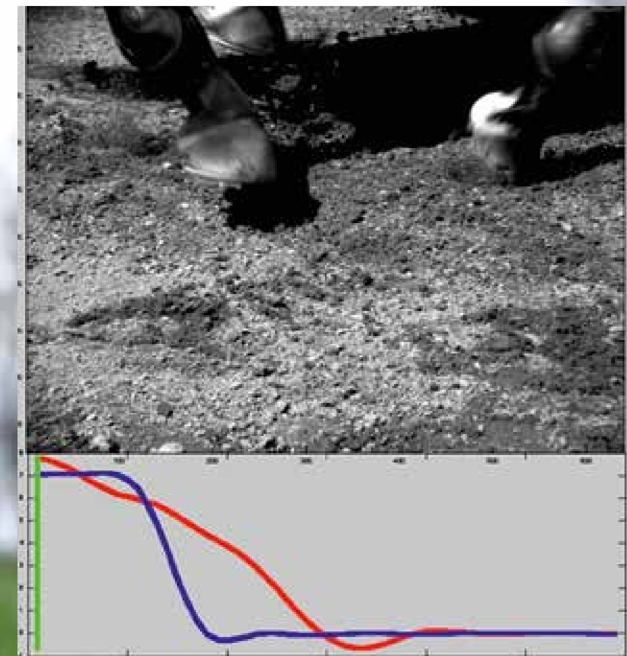
GRASS INNER HIND LEG



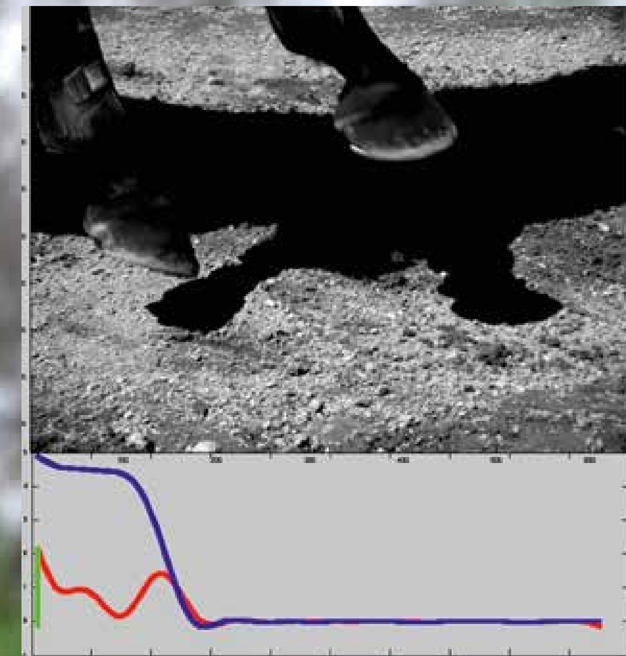
GRASS INNER FORE LEG

Hoof landing on sand only surface

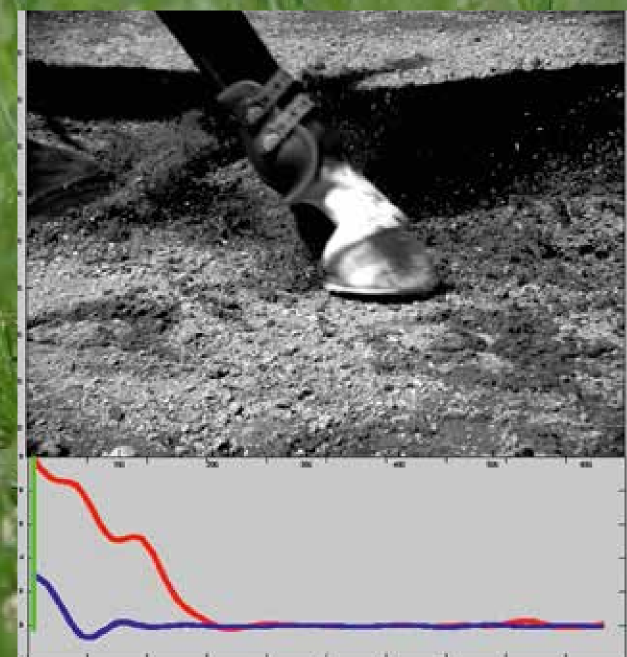
Films: Elin Hernlund Graphs: Lars Roepstorff



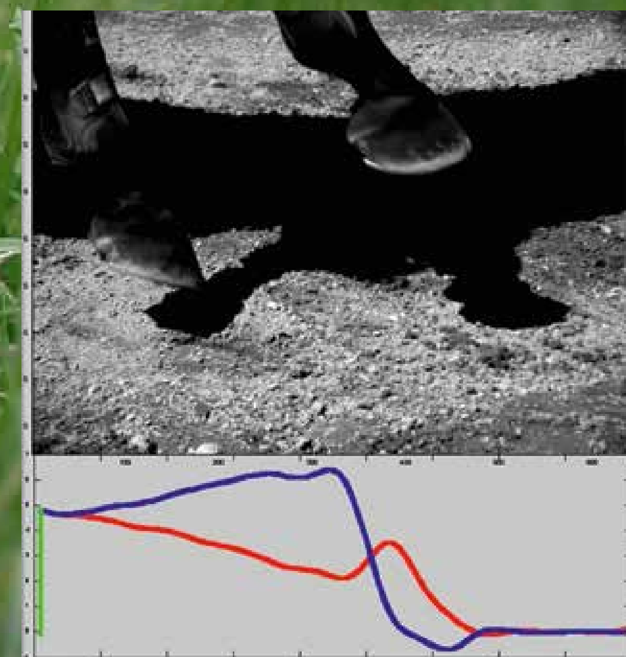
SAND OUTER HIND LEG



SAND OUTER FORE LEG



SAND INNER HIND LEG



SAND INNER FORE LEG

4 ARENAS, THEIR FUNCTION AND PROPERTIES

How a riding surface functions must be characterised based on how it responds to the load from the horse. It is important to find a common set of terms that define these effects.

Photo: Mikael Sjöberg

THE CHAPTER IN BRIEF

How do you characterise a riding surface?

It is the properties of a surface that affect the horse. To characterise a surface we therefore need to define terms to describe these key functional properties. With support from the FEI/World Horse Welfare the equestrian surface scientists in Sweden together with colleagues in the US, the Netherlands, Switzerland and the United Kingdom, have developed a "profile" to characterise riding surfaces. The aim of this profile is to offer all riders definitions that describe an arena, where the profile can also be evaluated objectively by mechanical testing **(see chapter 12 <u>"Functional testing"</u>)**. Try and evaluate your own arena using these criteria!

- Is the arena hard and rigid or does it offer shock absorption?
  THIS IS DETERMINED BY THE: Impact firmness and cushioning

- Does the surface offer the horse good traction and grip, but also help to absorb the braking force when the hoof first hits the ground?
  THIS IS DETERMINED BY THE: Grip and impact firmness

- Does the whole arena offer the same properties?
  THIS IS DETERMINED BY THE: Uniformity

Arena surfaces used in equestrian sports are mainly composed of sand and sand mixes. (Other types of arenas, such as grass arenas and those based on woodchips, rubber, dirt, etc are not included in this first edition of the guide). It is important to understand that especially sand based surfaces behave differently depending on what forces or loads they are subjected to and at what speed they are loaded. Imagine a mouse and a horse moving across the same arena – they would have very different opinions on how it feels! This is because a surface can feel stiff for a lightweight individual while it feels softer to someone who is heavier. This is because the lighter load does not deform the surface. This also means that what a rider feels when walking across an arena is likely different to what the horse feels.

When a horse lands on a surface, for example, after jumping a fence, the impact with the surface is at high speed and there is a large amount of weight loading the limb. Therefore the horse will "feel" characteristics deeper down in the surface compared to a human who tries to "test" the surface by jumping up and down in the same spot. For humans with their lighter weight it is easier to determine characteristics of the top layer.

This chapter describes five criteria to describe the properties that characterize a riding surface:

CLICK AND READ MORE
(scientific White Paper)

Photo: Roland Thunholm

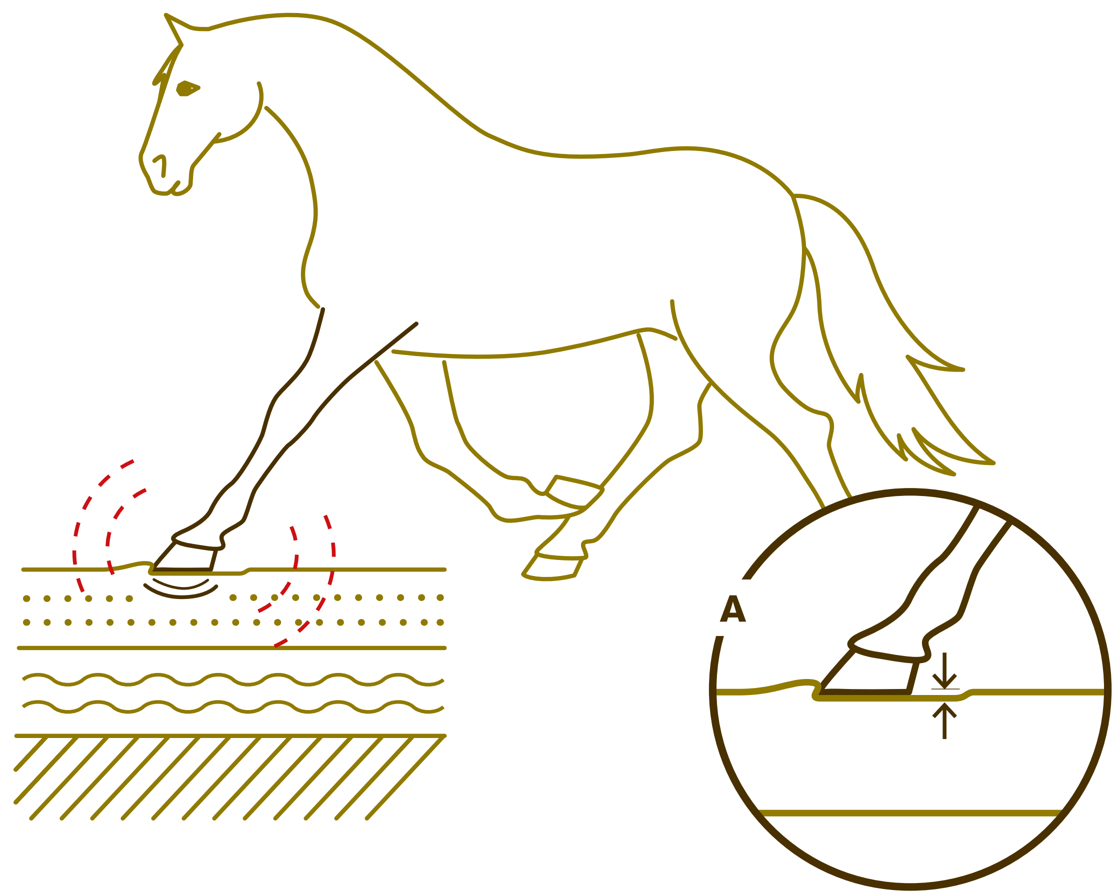
IMPACT FIRMNESS

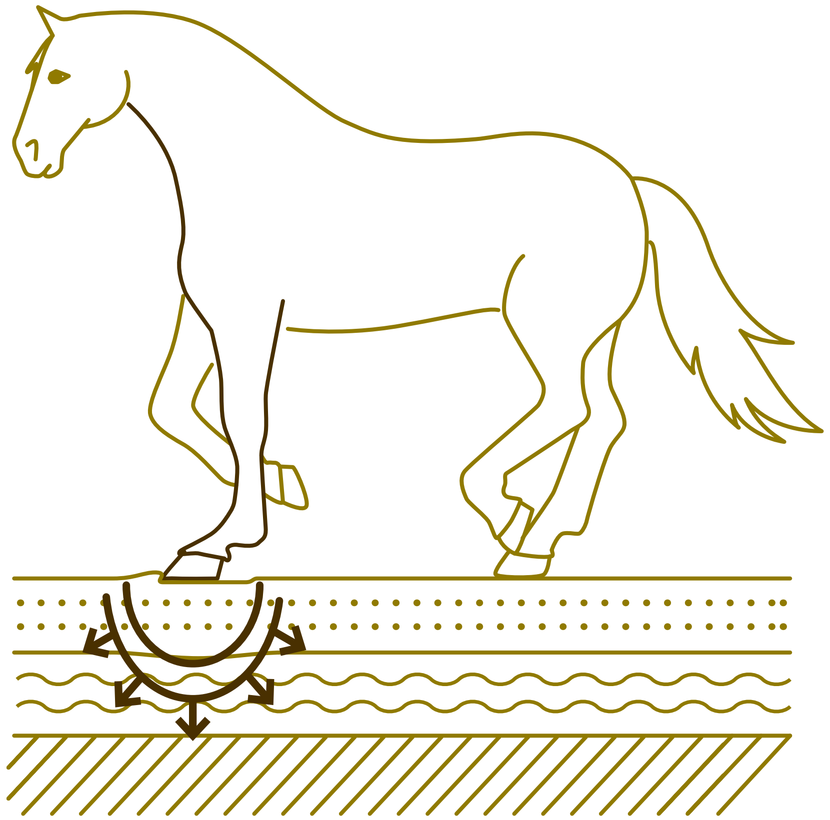
Influences the mechanical shock experienced by the horse when the hoof first hits the ground.

This relates to the hardness of the top layer of the surface. How firm/loose is it? How high is the impact shock when the hoof lands, and how much can the hoof rotate into the top layer? Tarmac and concrete have maximal impact firmness.

EXAMPLES: If you put a layer of a few centimetres of sand on top of the tarmac, the impact firmness would be considerably reduced, while the surface would still provide solid support for the hoof. Another example is if wooden boards were laid on top of wet clay to protect the horses' feet from sinking into the soft earth, the impact firmness of the wood would be greater than that of the sand on top of tarmac, but the surface would still give under the horse.

Drawing: Elin Hernlund and Linda Eriksson





CUSHIONING

Cushioning describes how the surface is able to dampen and reduce the maximum force, when the horse puts its full weight on the leg during the support phase.

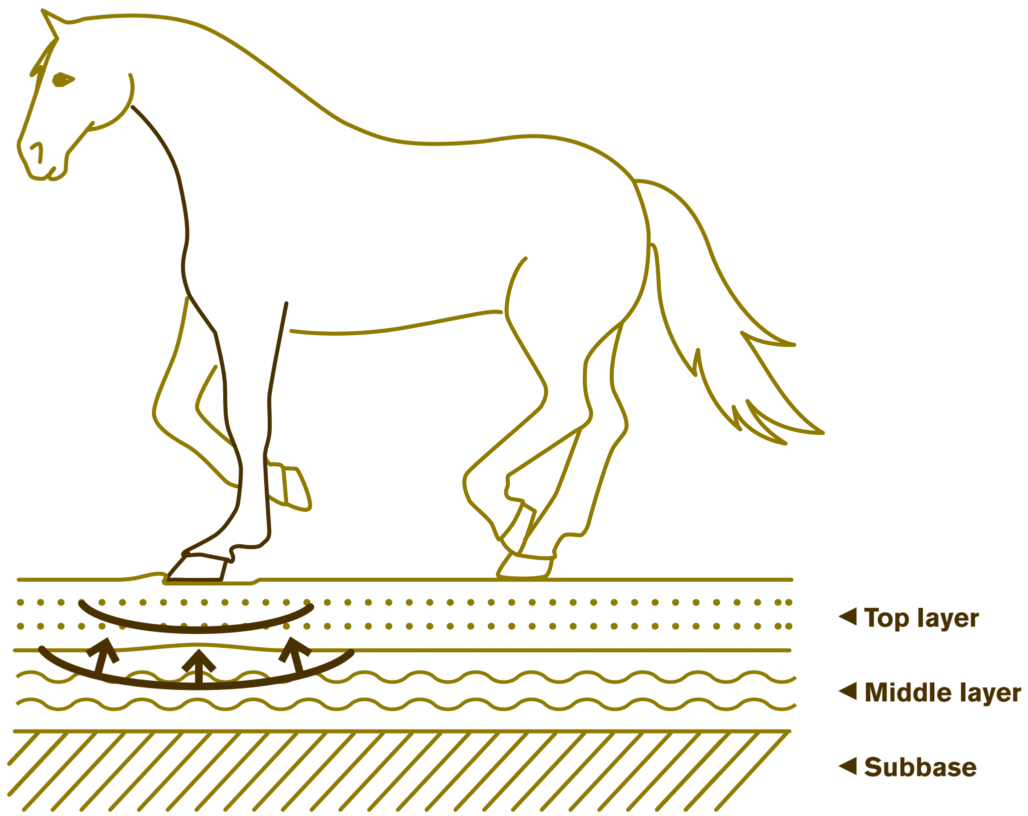
Cushioning (or force reduction) refers to how all the layers of the riding surface react to the force applied when it is loaded from above by the weight of the horse. A surface that provides good cushioning can reduce the stress and strain on the horse's leg when the hoof is in full contact with the ground. A surface with less cushioning is described as stiff or hard. Obviously there is also an association between the cushioning effect and impact firmness. When the hoof leaves an imprint on the surface due to compaction by the weight of the horse, this also provides shock absorption. It is nonetheless important to understand that cushioning is not only dependent on the hardness of the superficial top layer. A minor response in the lower layers can provide good shock absorption for the horse.

With riding arenas it is common to achieve cushioning by working with materials that deform under the hoof (by compaction). Decompaction can be achieved naturally with an "elastic" material (a moist fibre sand, a springy rubber layer beneath the surface), or by maintenance (harrowing). So cushioning be achieved either by a footing with a loose surface, or with an elastic footing. When we discuss cushioning we only mean the cushioning ability. The difference between an elastic surface and deep loose surface is discussed in the next parameter.

EXAMPLE: A compacted surface with no cushioning can help the horse perform very well because it provides solid support for the hoof, but the horse may also be injured much more quickly because such a surface offers very little shock absorption and the loads on the limb may become too high. On the contrary, a deep surface deforms as the hoof pushes against it, rather than resisting the push the push would provide too much cushioning. To perform well on this surface the horse would need to work harder, so may fatigue more quickly.

An example of a surface that has cushioning without elasticity is a sandy beach with dry, deep sand.

Drawing: Elin Hernlund and Linda Eriksson



RESPONSIVENESS

How active or springy the surface feels to the horse.

Responsiveness in a surface can be likened to using a trampoline; after the surface has been pushed downwards by the weight of the horse it can spring back and aid the horse in pushing off into the next stride. It gives energy back to the horse. The natural frequency (tuning) of the surface determines the timing of the rebound. If the rebound is well timed to the locomotion to the horse the surface will feel springy or active. The opposite is a "dead" surface. Responsiveness is also influenced by the stiffness of the surface, so it is closely related to cushioning. A very compacted surface may rebound too quickly to return energy to the horse, so it would also feel stiff, and "dead".

As the horse's body has a lot of inbuilt elasticity the responsiveness of the surface can be difficult for the rider to judge.

Drawing: Elin Hernlund and Linda Eriksson

GRIP

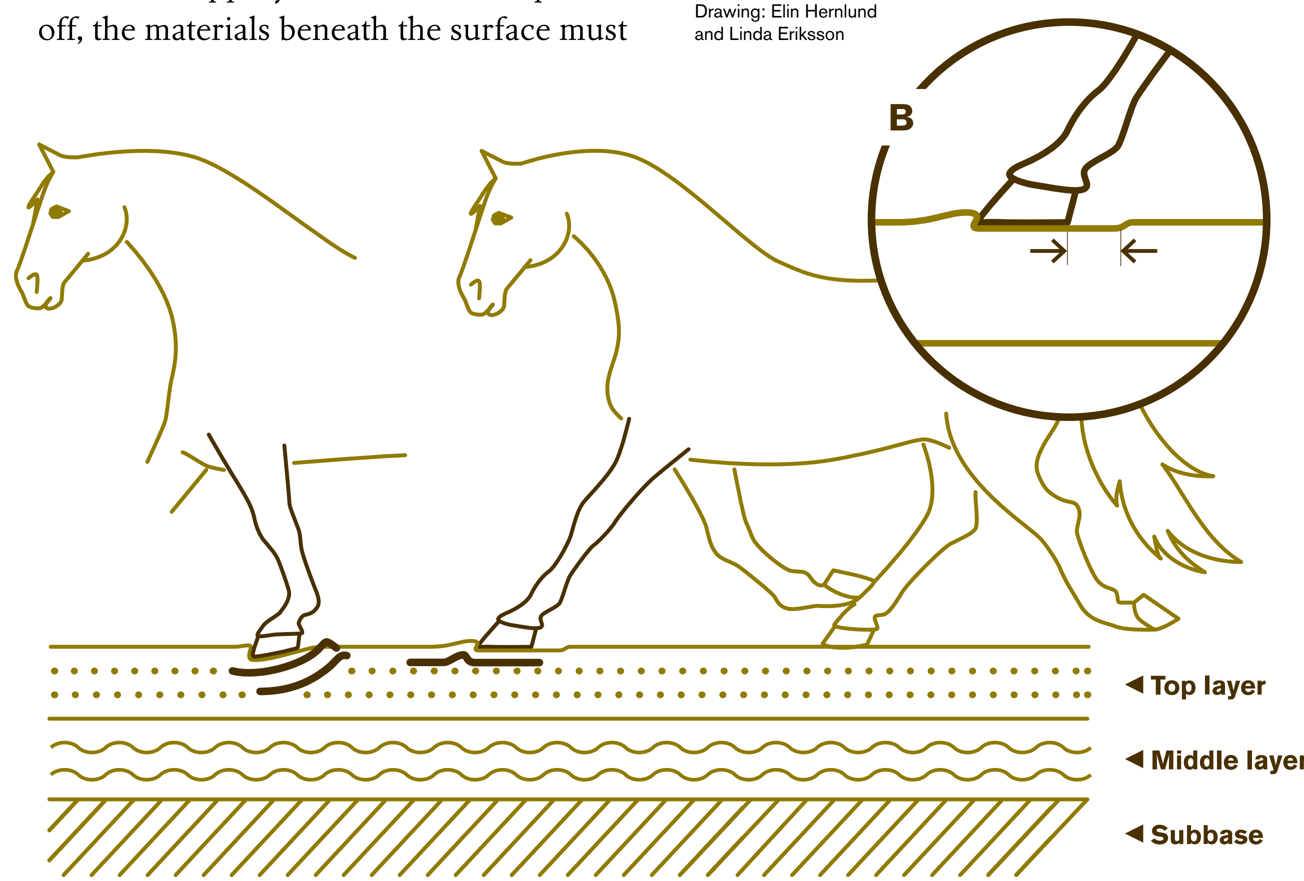
Affects how much the horse's hoof slides during landing, turning and pushing off.

Grip is determined by both surface friction and how well the top layer and the materials beneath interlock and hold the surface together to provide traction. Surface grip is important when the hoof lands, when the horse turns and during propulsion.

The friction on the surface affects the hoof landing. It is important that the hoof can slide somewhat on landing as that helps to absorb the impact. Meanwhile the hoof should not slide too much, as this means the surface is slippery. When the horse pushes off, the materials beneath the surface must withstand the push. The same principle holds on turns. At what angle the hoof lands and the speed of the horse is also important for how much grip the hoof needs and gets. Achieving the right balance of grip is a challenge for anyone wanting to produce a good riding surface as not too much and not too little is important for injury prevention.

EXAMPLE: A high grip surface would stop the hoof too quickly, whereas on a slippery surface the hoof would slide too much.

Drawing: Elin Hernlund and Linda Eriksson



UNIFORMITY AND CONSISTENCY

These properties are concerned with how uniform the surface feels from stride to stride as the horse moves over it. Remember that an arena can look even and yet not be uniform!

Uniformity describes how much the characteristics vary across a whole arena. A surface can be even and look level, but as you ride across it the impact firmness, cushioning and grip change. If these changes are quite small and gradual or readily visible the horse can probably adapt quite well. But if the variations within the arena are greater and more frequent the horse can find it difficult to adapt, and is more likely to trip, or even get injured. Some arena surfaces may also be unlevel in the sense that they are not flat, and are then likely to vary in their properties.

The profile or properties of an arena will change depending on moisture content and maintenance.

Photo: Roland Thunholm

5

CONSTRUCTION MATERIALS

Sand, gravel and other materials used for surfaces are a science in themselves. Chapter five gives an introduction and overview and points out characteristics that are valuable to be aware of when building or renovating a riding arena.

Photo: Svenska Ridsportförbundet

THE CHAPTER IN BRIEF

We often use the word sand for the material, which is the major ingredient in a riding arena, but this is a rather non-specific term. It is preferable for the material to be defined based on the following characteristics:

1. Is it natural sand or manufactured material from crushed rock?
2. What is the geological origin of the material?
3. Sand and gravel are granular materials resulting from the natural disintegration of rock or from rock crushed in a aggregates crushing plant.
4. The fraction of fine materials such as silt and clay.
5. Additional additive materials such as fibre, wax or wood.

These characteristics are important to understand since they affect the properties of your arena. One example is the size of the grains of sand, which are described according to their diameter in millimetres, mm. However, this does not describe the distribution of these sizes, which affects the properties of an arena. Availability of different sand qualities varies with locality and may influence your transportation costs. Research has found that you can get very similar properties in arenas with different materials. Therefore, you have a choice of solutions to obtain the "right" arena by, for example, adding other materials such as wood, wax, rubber or fibre to sand. The functional properties of sand are significantly affected by water (moisture) content. To find the best solution it is important to understand the properties of the materials and how you can affect them with maintenance.

It can be a challenge to try and understand something as different as sand and gravel when your real interest is horses and equestrian sport. But for someone who wants to build a riding arena it can be essential. As the consumer, you need to become aware of what factors influence the properties of the sand and the maintenance required to retain the properties of the material. The specifications of materials sold from quarries are normally insufficient. Hopefully, within a near future, we will have access to better analysis, which will provide more relevant information about the material before buying. Unless a ready-made surface is purchased form a commercial producer, in general it is best to get help from specialists with experience with the local materials and climate. In this chapter you can learn the basics for being an informed customer when planning a riding arena.

The first point to remember is that what we call sand in fact consists of varying proportions of:

- sand (particles in the rock material <63µm)
- air
- water

The first question when selecting materials for a riding arena is:

WHAT TYPE OF ROCK (GEOLOGY)

Sand and gravel are granular materials resulting from the natural disintegration of rock or from rock crushed in an aggregates crushing plant. Rock can vary in hardness, depending on the mineral content, which produces sand with different properties. The type of sand that is available is therefore determined by the geology in a region, and will vary between, and within, even small regions. Therefore your location will determine some of the properties of the sand available if you source the sand locally. The hardness and shape of the sand you choose will influence the lifespan of an arena.

Commercial producers of riding arenas and consultants normally prefer a high percentage of quartz or silica. The access to silica (quartz) sands varies between regions. The selection of especially silica sand requires some vigilance regarding dust, as fine particles can damage the airways. This is primarily an issue in indoor environments. It is possible for a rock to be both hard and fragile, such as porphyry, and the resulting sand will have a shorter life span. If you buy a ready-made arena surface it is important to find out about the composition of the sand beforehand and make sure that it does not contain excessive fine materials and is sufficiently durable.

▲ *Are you buying natural sand or crushed rock? To find the material that is best suited for your arena it is important to understand what affects the properties. The pictures show a glacial sand deposit being quarried.*

Natural sand

The selection of natural sand will make a great difference for arena properties. Natural sand, was once rock, but has disintegrated to small particles and is deposited in nature. In continental Europe one important source of sands are glacial deposits from the Ice Age. The grains have been "ground" by water, typically giving a more rounded shape. One type of natural sand is sea sand, which some producers regard as having grains that are too rounded and too similar in grain size, resulting in an unwanted ball bearing effect. Sand grains with a more angulated shape will hold together better but with greater wear on the hoof/shoe. The use of additives such as fibre allows this more rounded material to be used.

ADVANTAGES: Natural sand has properties which are beneficial in riding surfaces, with rounded and slightly angular grains.

DISADVANTAGES: Natural sand is a finite resource. Glacial deposits of natural sand can be an important source of groundwater. Some countries, including Sweden, have an official policy for a long-term reduction of the use of natural sand and aim for a changeover to crushed rock. Common problems with natural sand surfaces are that the sand is installed too deep, or with a suboptimal distribution of grain sizes.

Crushed rock

The alternative to natural sand is crushed rock. This is produced when a quarry blasts bedrock into different sized rocks and particles and then crushes the resulting material. The bigger fractions are called road base because that is one of the main uses (example 2-6, 8-16, 16-32 and so on; road base are sometimes also known as aggregates). The relatively smaller fractions that is called well graded road base is used in many arena constructions as foundation layer. Sand is the smaller particles with silt and clay sized particles as the finest fractions. The silt and clay are sometimes called fines, with clean sand having very little of the finer material. While the grains in natural sand are to various degrees rounded, having been polished by water over time, crushed materials usually have a much more angular shape. Just holding some grains in your hand you can feel they are "sharper". These more angular materials "hold" together better than natural sand because the sharp edges of the sand grains will contact the adjoining sand particles. You can utilise this effect to get the surface to "hold" together, but the result can also be that such a surface gets hard due to fine particles generated from fracturing of the corners of the sand, that in turn cause high degree of compaction. These broken corners effectively change the particle size distribution which in turn increases the surfaces ability to compact. An even distribution of different particle sizes compacts much more than a material that consists of the same sized particles. Crushed rock or manufactured sand is more angular producing good grip but it is likely to cause more wear on the horse's shoes (or hooves if barefoot) due to the abrasiveness of the angular grains.

ADVANTAGES: Unlimited resource. New methods for crushing are being developed may make it possible to produce functionally designed gravel, sand and fines.

DISADVANTAGES: Less durable than natural sand. Sharper grain surfaces that increase wear on the hoof/shoe. Requires know-how to produce a surface that does not compact too much.

▼ *Road base is often used in the deeper layers in an arena and is produced by crushing rocks.*

WHAT DOES RESEARCH SAY?
With modern methods of crushing rock you can achieve sand and fines with the ~~required~~ (rounded/ subangular) surface structure. This is being produced in small amounts in an ongoing research project led by Chalmers University of Technology in Gothenburg, Sweden. The project aims to develop products that can replace natural sand and gravel, but also improved and specialized products.

CLICK AND READ MORE
Chalmers Rock Processing Systems

Three important parameters used to assess sand and its properties are sand shape, size and sorting.

THE GRAIN SHAPE/ROUNDING

The shape or rounding of the grains particles is one of three critical factors in determining how the sand will function as a riding surface. This is somewhat an issue for the difference between natural sand versus manufactured. Natural sand will have rounded or subrounded grains, as over time the sharp angles have been subject to abrasion and impact with other particles, but the grain shape can vary significantly even in natural sand.

The tendency of more rounded sand grains to create a loose surface can, to some extent, be controlled by using a wider distribution of grain sizes and fractions. Some specialists suggest that “suitably” subangular or subrounded grains in natural sand produce a combination of dampening, cushioning and stability because they will not compact entirely.

In contrast, crushed rock materials have sharply angular grains when new.

Since 2002 there has been international standard classification of natural sand based on grain size (ISO 14688-1) (with further categories) but this describes those relevant in an arena top layer:

Gravel	2 to 63 mm
Sand	0.063 to 2 mm
Silt	0.002 to 0.063 mm
Clay	≤0.002 mm

HOW BIG ARE THE GRAINS?

The manner in which the size of the sand grains affects the performance properties of the arena is well accepted. Most people who have been involved in conversations about riding arenas have heard definitions such as “0-2 ~~(4, 6 etc)~~” or “100 sieve sand” used when describing the sand used in an arena. The separation of sand by size is performed by putting the sand through screens. 0-6 describes the higher and lower end of the grain diameter in millimetres. This description does not, however, mean that the sizes are evenly distributed between those two limits. In some cases there may even be a small proportion of grains that are larger than the specified maximum size. In general the most important characteristic of arena sand is actually the size of the pores between the sand. Smaller pores are created either by smaller sand particles or by larger particles mixed with smaller material that can fill the gap. The problem with the latter case however is that the material can sort out over time and become very hard, where smaller grains with a very consistent size will retain the energy absorbing characteristics which are so important in an arena surface.

The language associated with the sand can be confusing depending on the goal of the supplier and the type of material. A stable base is required when constructing roads or foundations for buildings. The material which is used for these applications is sometimes called well graded. This is a good material for a foundation for an arena but would not make a good top surface since it would compact and get hard, fine for house building but not good for horses. What these same suppliers would call a “poorly graded” soil both has better drainage and will not get hard as easily. The goals for sports fields or agricultural applications are very different and have developed separate descriptive wording as well, where “poorly graded” materials can become “well sorted”. The critical characteristic of an arena surface is that the material in a basic sand arena cannot have all of the grains of sand all of the same size or the effect can be compared to that of peas “rolling” in a bag. This will provide the horse with poor grip. When fibre or wax and fibre are added to this same material however, the opportunity exists to have a well sorted material that in combination with the synthetic additive will support the hoof of the horse. This type of surface with open pores and rounded but durable sand will tend to have higher initial cost, but will require less maintenance and will have reduced sensitivity to moisture content because of the ability to drain water through the surface.

If a grain of sand had the same diameter as the wheel of a bike, a grain of silt would have the same diameter as a bottle cap and a grain of clay would be smaller than the head of a pin.

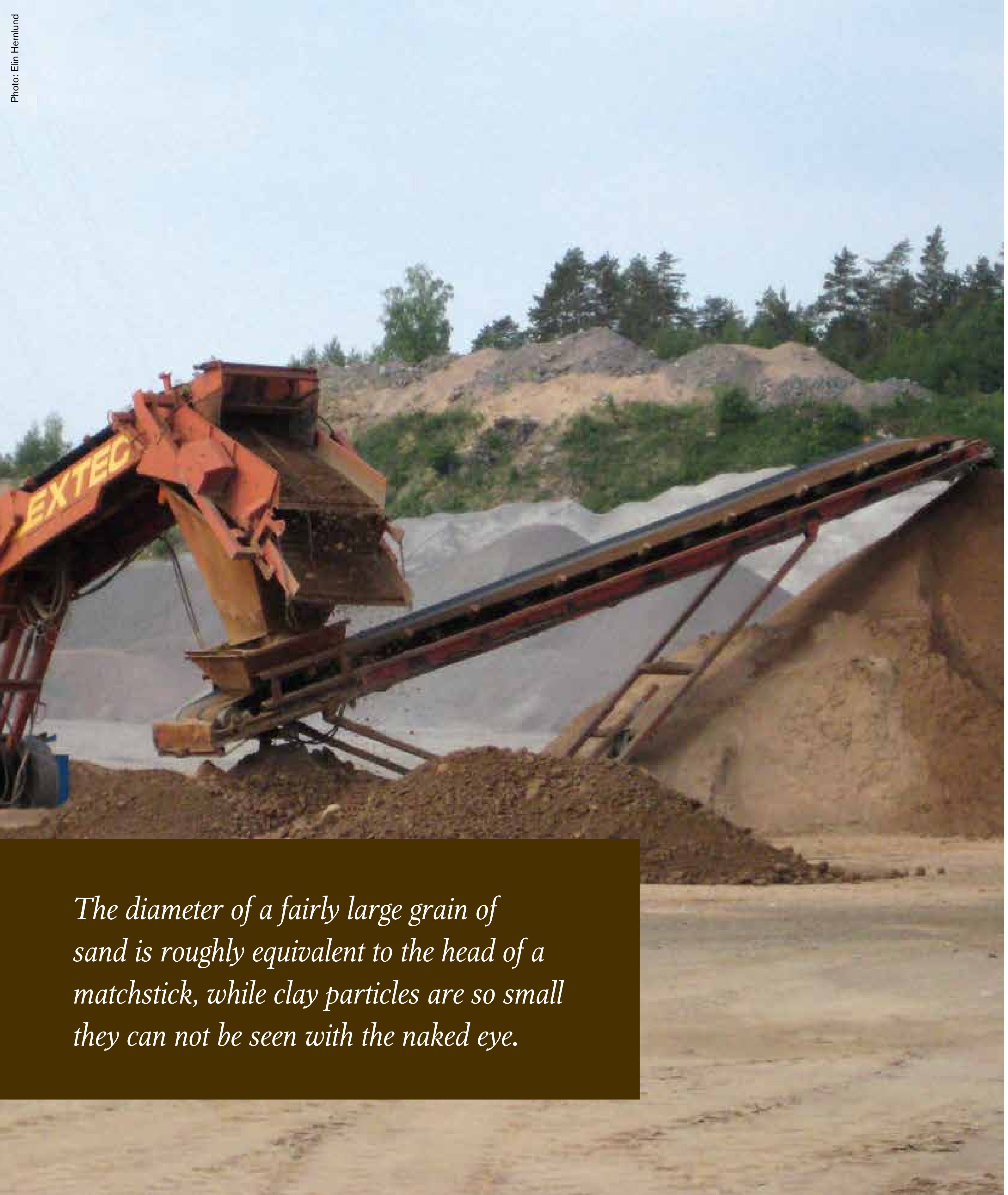


Photo: Elin Hernlund

The diameter of a fairly large grain of sand is roughly equivalent to the head of a matchstick, while clay particles are so small they can not be seen with the naked eye.

◀ *To produce wanted dimensions the quarry puts sand through one or several screens. Here such sorting is being done. The material is taken out and transported by a conveyor belt to a separate heap. In the background are heaps of crushed stone (grey material).*

SPECIFIC SIZE

As we have said, the size distribution of sand is very important for function, and is, therefore, essential information when ordering sand for an arena. To get a description, you order a sieve analysis from the quarry (or discuss with the contractor/producer). For the analysis the sand is separated through screens with progressively finer mesh, rather like wheat flour when divided into fine flour or wholemeal. A quarry can also mix sands into a predetermined profile for the customer. This test, like many with natural materials, is deceptively simple. Caution should be exercised when looking results with a larger percentage of fine material, silt or clay. The silt and clay can in some cases be very difficult to separate and make sand grains appear larger, either by covering their surface or by forming agglomerates of clay particles. Other methods are needed for profiling these materials, which involve soaking and use of chemicals to dissociate the clay particles. The test methods used are critical and incorrect results can result in the construction of an arena which may only be acceptable for a short period after installation.

FINDING SAND
The easiest way to locate a quarry or sandpit will differ between countries. In some countries the National Geological Institute will publish maps of local geology and access to sand. One solution is also to use the web engine Google Earth. Locate your local area with the satellite image, and write "sand" in the search box. This should produce a list of quarry companies with contact details, in your region.

MORE ON SAND AND FACTORS THAT INFLUENCE THE MATERIAL

How big is the natural fraction of fine materials such as silt and clay?

The smallest grain size which will be specified in a sieve analysis of natural sand is normally at 0.063 mm in diameter. It is important to also know how much of the material is smaller than that. The smallest grains are not sand but particles of clay, silt and various biological sediments from nature (humus). This can be classified as "filler" or "fines". That is also the name for the finest particles in crushed materials.

In fact there are other critical characteristics of the smaller particles that are more important than the size. In general is it best to refer to the small particles identified in standard size testing (sieve and hydrometer) as clay sized particles, since the actual minerals and flat shape of some clay result in a dramatically different behaviour than what would be expected from simply smaller sand type particles. Therefore what we call arena sand can include materials which range in size from even fine gravel down as small as to include tiny clay sized particles.

These clay sized particles can have both advantages and disadvantages for arena properties, as mentioned earlier. There are different opinions on how big this fraction should be. Some expert consultants have a guideline percentage of about 2-4% percent of filler. Some commercial producers recommend the use of fine sand with some 15% of clay/sediment particles, which will increase the tendency to compact. Crushed materials also have a proportion of "filler" consisting of particles less than 0,063 mm in diameter. One aspect of the finest particles is that, over time, they can cause clogging/blockage of the arena drainage.

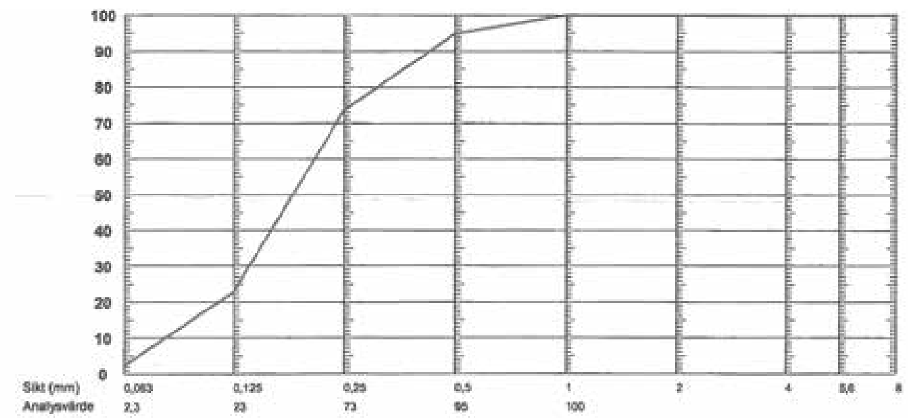
CLICK AND READ MORE

To find out more about how clay affects the properties of a surface follow the link and open the document "The role of clay in racing surfaces". This is an article written by American surface researchers who are part of the review group for this document.

What is "washed sand"?

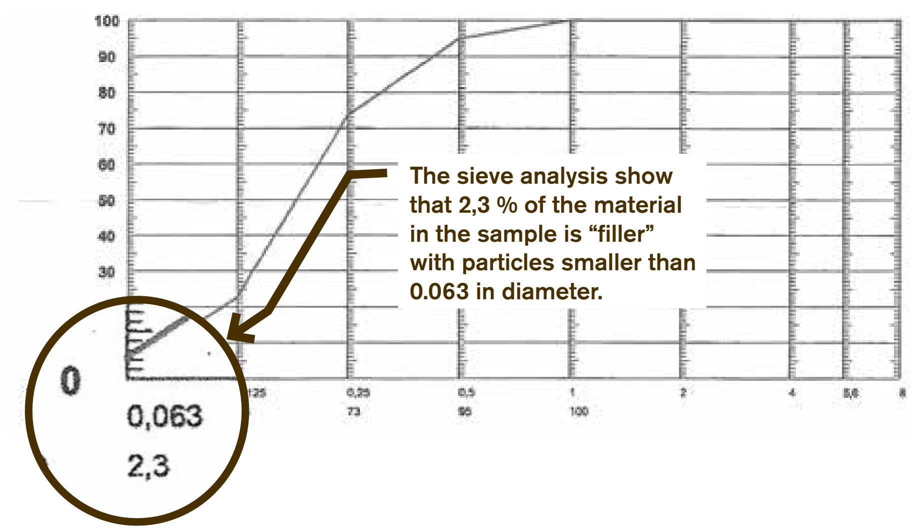
This is sand in which the smallest particles have been washed away. Washed sand is very useful if, and when, anyone wants a specified grain size to be included in a surface, or to add to an existing one. The disadvantage, mentioned earlier is that washed sand is used on its own, when the smallest particles are missing and all grains are about the same size, the surface will provide less grip/traction. Crushed material can also be washed.

SIEVE ANALYSIS
Material passed



Sieve analysis chart: The graph shows a sieve analysis from a quarry with sand at a sorting of 0-1. Each vertical line represents the size of the "net" in the sieve where the sand has passed through. The y-(horizontal) axis shows which proportion (percentage) of the sample that has passed through. This shows a stepwise distribution of the sample material. It is very important that the sample analysed reflects the whole batch of sand you order.

SIEVE ANALYSIS
Material passed



The same sieve analysis but additionally showing the proportion of filler. A standard sieve analysis chart starts at 0.063 mm, which is the size of the finest mesh in the sieve. The chart will therefore not start at 0, as a percentage of the sample is smaller than that classification. This portion is called filler. This is silt and clay and very important for the sand and surface properties.

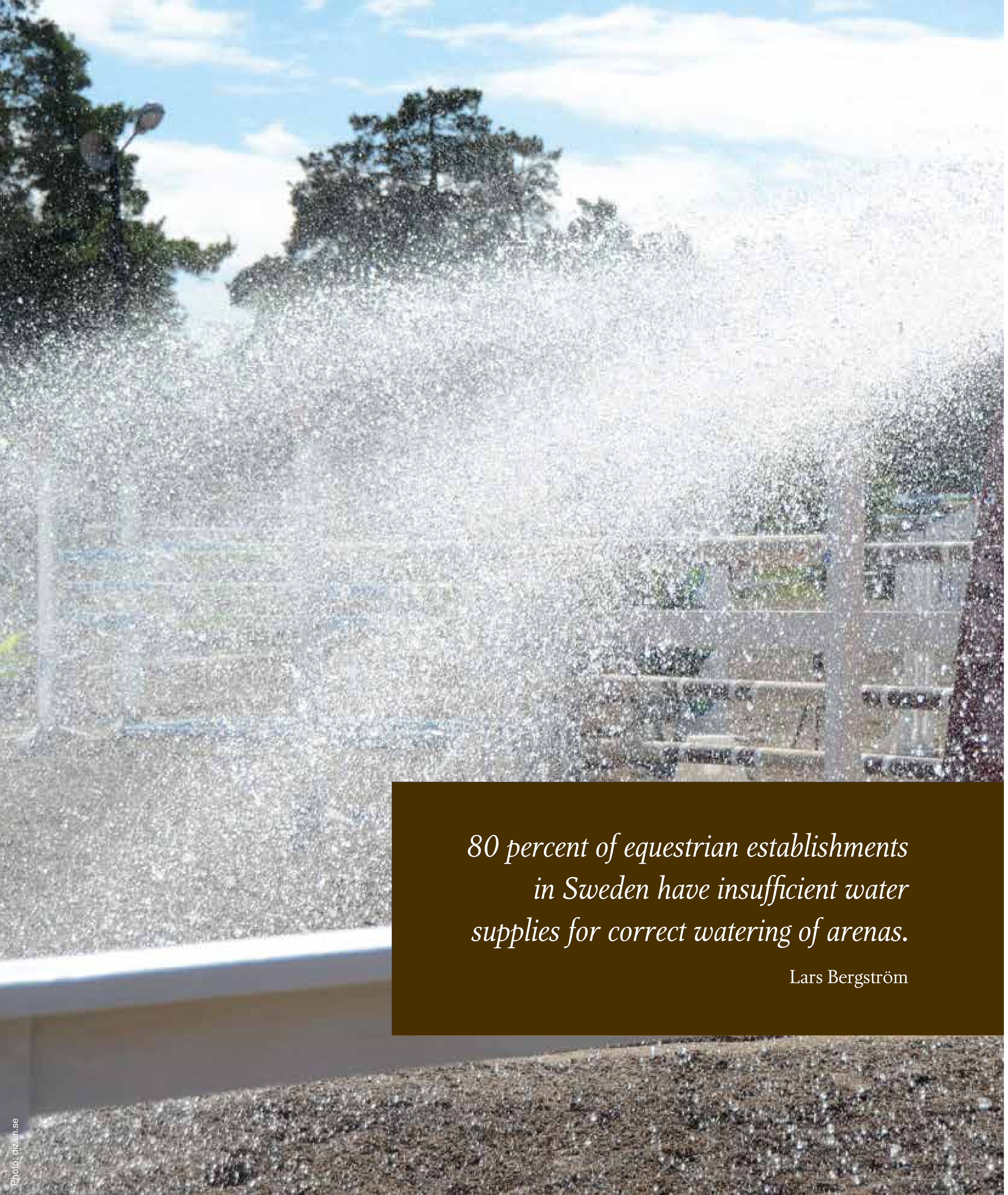


Photo: dizain.se

> *80 percent of equestrian establishments in Sweden have insufficient water supplies for correct watering of arenas.*
>
> Lars Bergström

Water

Water is the single most important factor that influences the properties you want from an arena. Water is also discussed in the chapters on Construction and Maintenance. Moisture to a high degree determines the properties of the sand, and therefore also of the arena. A good example is a beach by the sea. Compare walking or running at the edge of the water, where the sand is even and saturated by water from the waves, or away from the edge where the sand is dry and often deep. If the water content is too high the sand will start "floating" and the surface will again be too loose.

A good supply of water and a good watering system are, therefore, very important to consider when installing an arena. If the stable/establishment has a limited water supply there are alternative solutions:

- Buy water in a tank
- Organise collection of surface water, for example, rain water (in some countries this can be subject to laws and regulations)
- Consider a waxed sand surface, which requires less added moisture
- Subsurface watering also called "Ebb and Flood" systems save water by adding the water under the arena surface and thus reducing evaporation

One solution for riding surfaces that has been developed in continental Europe where water is the main ingredient is the Ebb and Flood system. The top layer consists of sand only or with a proportion of fibre, that is kept moist from beneath. Arena surface properties are controlled by the moisture level, and with the right construction the whole arena will maintain a consistent degree of moisture. The system requires specialist know-how to install, including careful selection of the sand. The so-called "flow point" varies between different types of sand, and is especially important when the sand is kept thoroughly moist as in this system.

▲ *Fibre and textile can be an ingredient in the top layer.*

ADDITIVES

Worldwide there is great variation of different materials used in surfaces for equestrian sport, mainly mixed with sand, but also as the sole material. In the following we will discuss a couple of materials more commonly used in mixtures with sand. Remember that with the correct maintenance (control of moisture content and mechanical interaction) different materials could be used to achieve the desired properties of an arena. In a global perspective we also have very different prerequisites concerning environmental factors such as rain, humidity, temperature and wind, which could substantially influence how different materials behave.

Fibre and textile

Fibre and textile have been used in riding surfaces for more than 20 years, with the aim of improving functional properties, increasing shear strength and stability and reducing maintenance requirements. The effect of adding fibre to sand based sport surfaces is well established in the scientific literature but the effect on the sports horse is not well documented. Suggestions below are therefore based on the practical experience of international arena consultants.

The effect of textile fibre is explained in terms of increasing the binding between sand particles. The sand particles dig into the surface of the fibre creating a surface is somewhat like sand paper, which resist the sliding of the neighbouring particles and thus will increase grip and friction. The market for equestrian surface fibre is not standardized, and thus it is important to specify materials in a manner, which ensures that the surface gives the desired characteristics.

Like sand, there are great variations between the materials and shapes of the textile additives for arenas. Some vendors provide shredded carpet for this application, with others having a similar product which is cut and with the backing material removed. Single fibres and yarns are also used with both new and recycled materials used for the fibre for riding arenas. In general, longer fibres are used in smaller quantities, but can be more difficult to distribute and make maintenance more difficult. Small rectangles of material can also be used which also require less material. The shorter single fibres or yarns are typically easier to maintain but requiring larger quantities. Both the stiffness of the fibre and the strength also affect the quantity and durability of these additives. The pricing also varies greatly, from 0.20-0.30 euros to 1.50 euro per kilo (in continental Europe).

Three important criteria to consider when ordering fibre or a fibre mix:

- **IS THE TEXTILE/FIBRE CLEAN?** Rubber or glue backing material (in recycled carpet) can be present, and some people question the environmental effects.
- **SIZE?** Textile and fibre are sold both as pieces and as fibres or yarns. Pieces of textile bigger than 3x3 cm, or 3 cm long for a fibre thread, make the surface more difficult to maintain.
- **SENSITIVE TO ULTRA-VIOLET LIGHT?** If a material is not resistant to ultra-violet light from the sun, there will be rapid degradation with dust formation, which will shorten the lifespan of the arena.

Proportion of textile and fibre

The proportion of fibre can be measured as kilos per ton of sand or per square metre. The quantity of fibre is dependent on the type of fibre and the shape. In addition the shape of the sand will also have an influence on the effect of the fibre on the final surface material.

The advice given here is again based on practical experience, and effects have not been mechanically tested.

Guidelines:

- **LOW PROPORTION OF FIBRE** (suitable, for example, for riding schools and other users that do not wish for a high degree of grip/friction but want to take advantage of other effects of fibre: 10 kilo per ton of sand or 2-2.5 kilo per square metre of sand (see advice on choosing sand below).
- **HIGHER PROPORTION OF FIBRE** (for example, for competitions with better grip for higher speeds): 12-16 kilo per ton sand or 3 kilo (range 2.5-3.5 kilo) per square metre.

An even higher proportion of fibres, such as 4.5-7 kilo per square metre of sand or 40-45 kilo per ton of sand, produces a very high degree of grip with correspondingly increased load on the leg and is rarely used for riding arenas.

Choice of sand for fibre surfaces

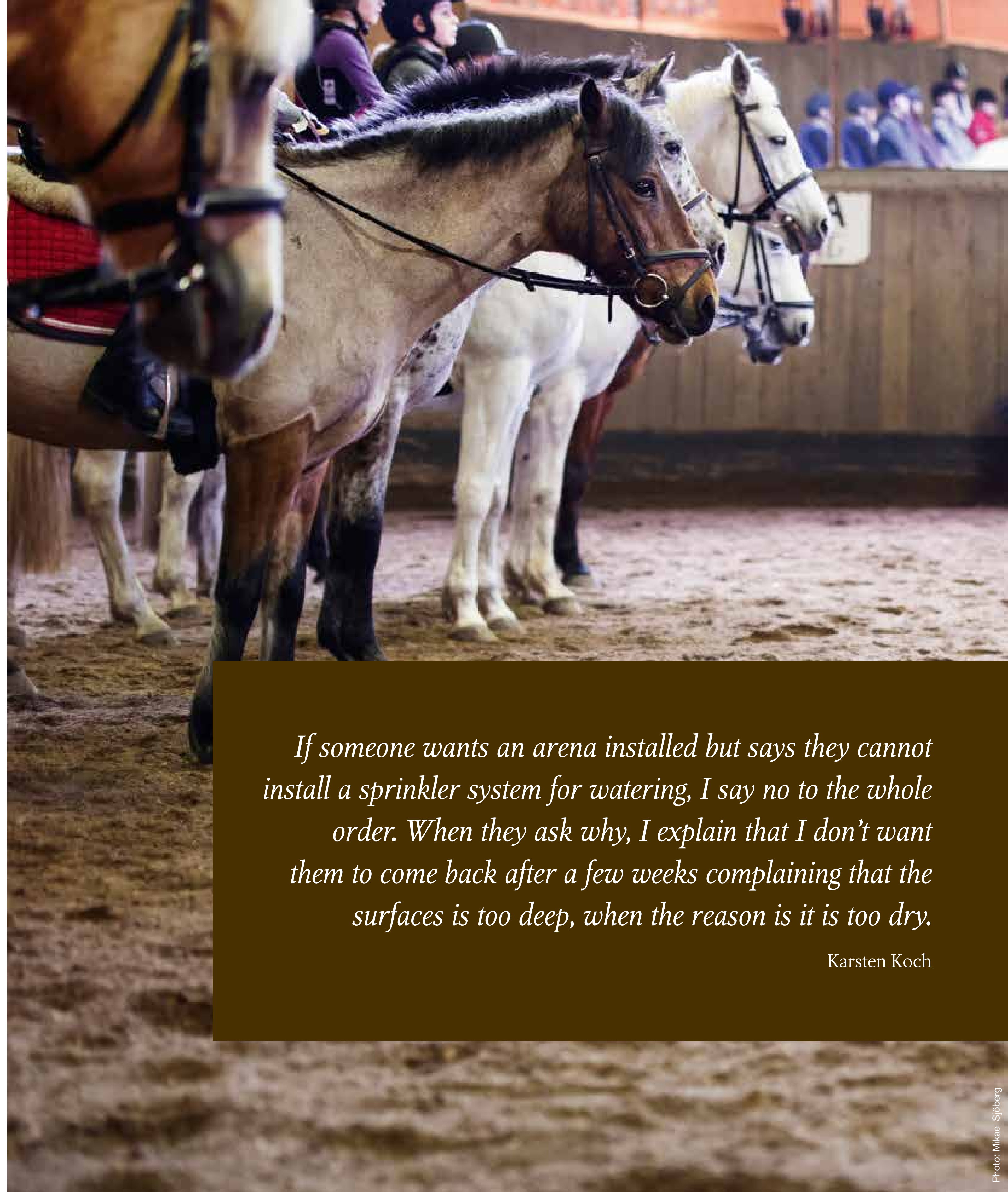
INDOOR: Fibre is best suited for mixing with fine sand at diameters of 0-1/0-2. The fine sand adheres better to the fibre compared to coarser sands. Another recommendation for sand used with fibre is to have a low proportion of filler (maximum about 5 %). The sand used by commercial producers of fibre sand arena surfaces at an international level is typically very clean with little or no silt and clay and with a very high proportion of silica. Silica sand is an example of a durable (and more expensive) sand. Durability means that the sand is not being crushed by the wear from the hooves. If the sand grains are getting crushed relatively more fines will be produced, which could lead to decreased vertical drainage capacity.

OUTDOOR: If the fibre sand arena is installed in an outdoor location it may be required to withstand heavy rain. Coarser sand can then be used, and there should be almost no fine material in the surface to maintain horizontal drainage. Often in an outdoor arena a slope is also used so that in the case of very heavy rain both vertical and horizontal drainage will occur.

Installation and maintenance of fibre surfaces

For a fibre sand mixture to function correctly it is important that the sand and fibre are mixed and properly watered. Mixing can be done at a factory or done with a rotavator/rotary tiller at the installation. If the sand is allowed to dry out, the fibres can accumulate on the top surface during maintenance or in dry conditions without watering. Remixing of the material must then be done carefully, especially if the material has moved, to avoid damaging the foundation material.

A fibre sand mixture requires considerations about final disposal at the end of the useful life. A well maintained fibre sand arena can last for 20 years, but will be classed as waste when it is time to replace it, and this can be costly. Methods to shift the sand and fibre for recycling do exist and are also being developed.



If someone wants an arena installed but says they cannot install a sprinkler system for watering, I say no to the whole order. When they ask why, I explain that I don't want them to come back after a few weeks complaining that the surfaces is too deep, when the reason is it is too dry.

Karsten Koch

Photo: Mikael Sjöberg

WHAT DOES RESEARCH SAY?
A scientific study published in 2013 by the equestrian surfaces group at SLU about surface use, training and injury in Jumping horses indicated an association between use of sand-wood surfaces and less risk of days lost to training due to injury." The article is also mentioned in the training chapter "Training for soundness and performance".

WOOD (CHIPS/SAWDUST)

Woodchips, sawdust or other biologically degradable material is a main ingredient in many surface mixtures around the world. Woodchip only surfaces are seen occasionally but not discussed here, although some aspects such as degradation are relevant in both cases.

ADVANTAGES: Renewable resources. Easy to dispose of at end of use, due to the non-synthetic contents. The wood aids responsiveness/elasticity, and helps the sand to be stabilised, but it is important to combine it with the right type of sand. A surface containing wood has a shorter "lifespan" than fibre sand, but is substantially cheaper to install and serves as an alternative that with good maintenance will function well also for competition (though not the highest levels) and training.

DISADVANTAGES: Naturally bio-degradeable, can then get slippery and needs top-ups/replacement, resulting in shorter intervals for end of use or renovation. With removal of manure the risk of slipping and lack of grip are reduced.

Like sand, different types of wood have different properties. This will influence the lifespan of the riding surface, as different woods will degrade slower or faster. One guideline for sand-wood surfaces is that the top layer will need replacing every three to five years.

Oak, for example, will last longer than pine, and pine will last longer than fir. This is due to the trees' strategies to resist attacks from fungus, but also provides resistance against mechanical wear from hooves. Sawdust from pine has been easy to source in Sweden. As it is degrades quite quickly there has been a tradition to do "top-ups" every year. Meanwhile the remains of the old wood are still there, and in combination with old manure in arenas that are not mucked out, this can result in a slippery surface from the degraded organic material. However, as is pointed out elsewhere, if the arena is mixed deeply through deep harrowing and air is introduced into the surface then this problem is avoidable.

Examples of more durable woods are larch and oak. Based on experience woodchips that are the size of match sticks work particularly well but this is not a standard order. The ease of disposal of wood sand mixtures is an advantage of these types of arenas, since it can then (with permission) be put out on farmland for disposal unlike the sand fibre surfaces.

Choice of sand for wood mixtures

The sand that is mixed with wood should preferably be fine natural sand, at 0-1 mm. You can choose 0-2 mm, but then the proportion of 1-2 mm should be no more than 10 percent. The proportion of filler should be low, maximum 5 percent. The proportion of wood in the whole mixture should be about 30 percent.

WAX

Wax-coated sands are used more commonly in some countries and are typically seen when particular performance characteristics are desired. These surfaces also provide reliable vertical drainage.

ADVANTAGES: A choice that requires less watering than others. A good alternative for anyone looking for strong cohesion and friction in the top layer without lots of filler particles that can compact into a crust deeper down or clog drainage. An outdoor arena with wax-coated sand can absorb a lot of rain if the drainage is correctly installed. Maintenance can be less intense than for other surfaces.

DISADVANTAGES: The material can be difficult to dispose of at end of use. Waxed surfaces can also be more sensitive to changes in temperature, getting harder in cold weather and very soft/loose when warm (which can be addressed with maintenance). Like fibre, waxed surfaces are included in the discussion on increased friction on the hoof. The wax can wear away from the sand over time and the sand may need "rewaxing", which can be costly.

WAX AND TEMPERATURE
Wax coated sand is one option for arenas, that, for example, is less sensitive to moisture. At the same time wax arenas have been shown to be affected by temperature. Here you can read a publication by Professor Mick Peterson about waxed sand properties on racetracks, related to temperature.

CLICK AND READ MORE

Photo: Svenska Ridsportförbundet

"Manure kills all riding surfaces, irrespective of the material."

Oliver Hoberg

OTHER MATERIALS

Apart from wood. fibre and wax other materials have also been used as additives in riding arena across the world. In many cases it is recycled materials, most often rubber, often from recycled car tyres. Rubber has also been tested beneath the top layer. In Germany recycled products, such as polyethylene, are used in sand mixtures. In the past recycled, shredded cable has been used but is no longer allowed in many parts of Europe, due to risk of environmental contamination from metal residues.

UNWANTED MATERIAL – MANURE

Horse manure collects more quickly on an arena than most people realise, and becomes an ingredient in itself with a negative effect on properties. In a sand-wood mixture the manure will mix with the wood into a compost-like organic material. When sand-wood arenas are said to be slippery the reason is often a layer of manure below the top surface. In a wax-coated sand arena manure and urine will alter the behaviour of the wax, and in fibre-sand mixtures manure also shortens the length of use. If a stable, or establishment, finds daily mucking out of the arena difficult to arrange, the suggested solution is to replace the whole top layer perhaps as often as every three years.

Remember that outdoors other organic material such as leaves can also have unwanted effects. If left on the arena they will degrade and change the composition of the surface.

MANURE ARITHMETICS

If every horse produces manure once during each session in the arena the manure will have a volume of about 2 litres. With 50 horses a day using the arena and no mucking out this will mean 100 liters of manure daily being mixed into the surface. After three years 50% of the top layer will represent manure.

Oliver Hoberg

IN DEPTH

In some countries including, for example, Sweden natural sand is rated as not a renewable resource. There are therefore government policies to reduce demand, for example, through higher tax on natural sand compared to crushed rock. See also link about Swedish research on alternatives to natural sand.

CLICK AND READ MORE
Chalmers Rock Processing Systems

Photo: Roland Thunholm

6 BUDGET

A good arena, which has been correctly built and is correctly maintained, can last a long time.

THE CHAPTER IN BRIEF

Costs are the first point to consider before constructing a riding arena. It is very important to produce a thoroughly analysed budget before commencing. Anyone planning a riding arena should take into account:

- PERSONAL RESOURCES AND LOCAL CONDITIONS
  (private or business finances, ability to do own work, climate, local soil, resources for maintenance etc.)

- THE INTENSITY AND TYPE OF USE OF THE ARENA
  (type of stable/equestrian centre, competitions/training only, discipline, number of horses etc.)

- OTHER COSTS
  (staff or own time for maintenance, machinery and other equipment, longevity of the arena etc.)

PERSONAL RESOURCES AND LOCAL CONDITIONS

When considering installing a riding arena it is very important to begin by analysing and taking advice on whether you have the skills, time and equipment to do all, or part, of the work yourself. What would be the costs and effort involved if you "Do It Yourself" (DIY), or hire a local entrepreneur, or a commercial surface specialist who installs an arena ready for use? The answers will vary between countries and within the same country.

Do you maybe have your sight set on a choice of material which, for whatever reason seems unrealistic? There might be a solution that means you can still achieve the properties you want, within your budget, if you can do some DIY work. Advice is included in the Materials chapter.

One important step is to invite tenders for materials and the construction work, review the tenders and get references from other customers on the end result and function. This concerns the arena properties, so that your goals for functionality are met. (The tender process and alternatives for construction are described in **more detail in Chapter 8 "Construction principles"**).

THE INTENSITY AND TYPE OF USE OF THE ARENA

How do you choose an arena surface? It is important to consider the main use of the arena, the number of horses that will use it daily, whether it will be used for competitions/shows and whether you have access to other areas for riding, such as fields or riding paths.

Weigh your needs for an outdoor versus indoor arena. Is it important that the surface has an "all weather" capability? What part of the year do you need it most? The choice of materials and construction should be strongly influenced by how the arena is expected to function in different weather and temperatures. **The heart of the matter is what properties the arena will have, and the goal for those characteristics must be defined from the start!**

OTHER COSTS

It is important to remember that the final cost of an arena is not only determined by materials and the construction, but also maintenance, including work time and equipment/machinery, renovations, expected "lifetime" or length of use, and (depending on country) final disposal. No arena will meet expectations without correct maintenance and the "lifetime" will be shorter without appropriate maintenance (see the chapter on Maintenance).

The length of use (with acceptable function) of a riding surface can vary from three to 20 years depending on choice of materials, wear and maintenance.

In some countries, for example the EU, a riding surface may be classified as a waste. The fees for final disposal of high volumes of waste should to be taken into account in the total budget. When such fees exist, great cost differences can occur. Disposal of natural materials such as a sand-wood mix, (that can be applied to agricultural land) can be relatively cost-effective. Surface mixes containing synthetic materials such as fibre and wax may require more complex waste disposal and incur higher costs.

Photo: Anna-Maria Jonuks

7 ENVIRONMENT AND SUBSTAINABILITY

It is important to evaluate how the arena material might affect the environment. This concerns both surface water drainage and end of use disposal. Start by contacting your local council to find out about the regulations that are relevant to you and your arena surface.

THE CHAPTER IN BRIEF

Environmental rules and considerations for riding arenas vary greatly between countries and even between local municipalities, from none to very detailed. The decision to analyse the environmental impact and sustainability aspects of an arena can be a personal choice or official requirement, to include energy use, potential climate impact, and local conditions regarding potential environmental contamination and method of disposal.

When installing a riding arena it is therefore important to be informed about and adapt to local laws and regulations. This is irrespective of what materials are used and how the arena is built.

To prepare for any official permits it is important to organise a written description of the surface composition with any materials listed. Use of certain surface materials such as rubber are restricted in some countries due to potential contamination. Water use and drainage can also be subject to local or national rules.

Longevity of an arena surface can vary and is often dependent on its makeup, location (particularly indoor or outdoor) and maintenance. Arenas with high organic content (i.e. woodchip) will breakdown (particularly outdoors) much faster than an equivalent sand or sand/fibre surface. At the point of installation, consider potential routes of disposal. The most environmentally optimal "disposal" route for an equestrian surface is re-use and/or renovation.

Renovation may involve the addition of extra sand and/or fibre along with the re-laying of the surface. When selecting a surface type, check that renovation is a realistic option **(see chapter 11 "Maintenance and renovations")**.

For a surface to be re-used in another form (i.e. non-equestrian), the individual constituents require consideration. For example, wax and fibre components may restrict its re-use as a soil improver or top-dressing in agricultural land. Similarly, sand (with additional fibre) would potentially not be suitable for use in building and construction; it may however find a use in road aggregates.

Complete disposal to landfill should be deemed a last resort. In countries where a cost per ton is incurred for landfill disposal, this route will be expensive. Some reduction in landfill costs can be achieved if the waste is deemed to be inert (see wastes acceptance link below for further information).

Different countries and regions will have different regulations. We are showing some UK examples that will to some extent also apply to other E.U. countries:

CLICK AND READ MORE
(scientific White Paper)

CLICK AND READ MORE
UK Wastes acceptance guidance.

CLICK AND READ MORE
For more information on recovery
see the following document.


Photo: Lavaletto

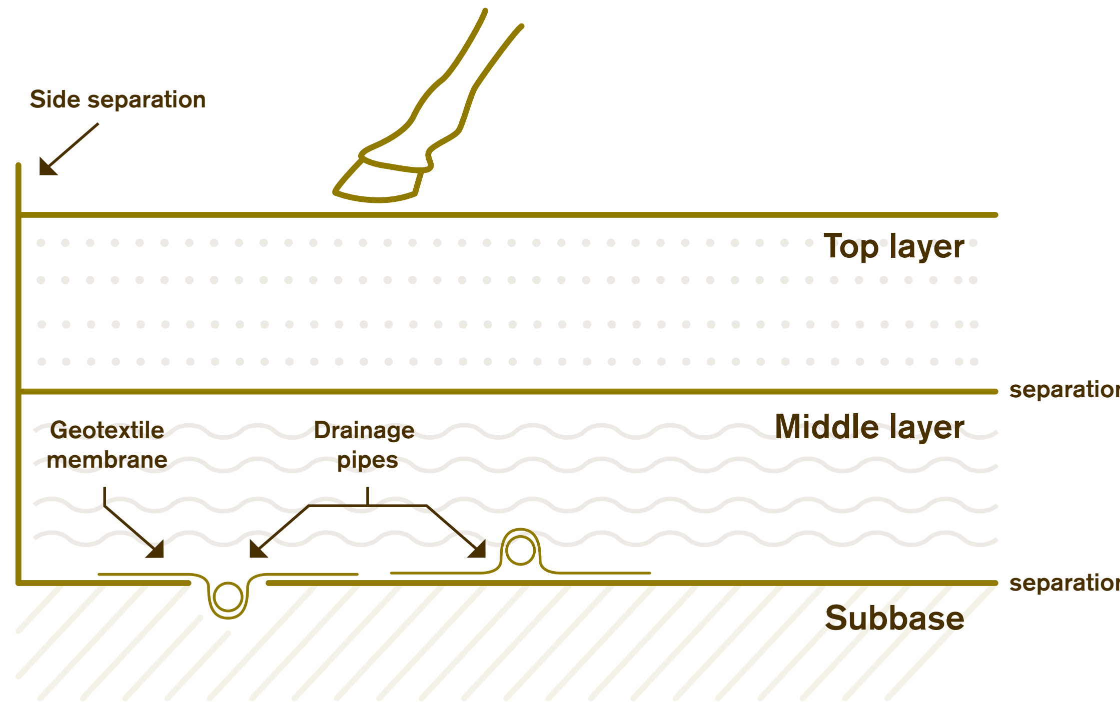
8 CONSTRUCTION PRINCIPLES

The base of the arena is very important in relation to how the arena will function. If the base is well constructed from the start it will make a big difference as to how long the arena will last.

THE CHAPTER IN BRIEF

The base of the arena is very important for how the arena will function. If the base is well constructed this will make a big difference for how long the arena will last. If, for example, the drainage is not working it makes little difference how carefully the top layer has been selected. A very important part of preparations is to analyse the local soil and other aspects of the land used. **Read more in chapter 9 ”The Building Process”.**

The fact that clay and sandy soils are different to ride on is a common experience. To protect from and compensate for variations in the ground, it is necessary to start by constructing a base. At a small establishment with few horses on sandy ground it might be possible to install an arena without the base described here, but in most cases the base is of vital importance for arena function.



PRINCIPLES OF ARENA CONSTRUCTION

An arena always has a base and a top layer. Depending on the composition of the top, the design of the arena and base layer there can be a middle layer. Most permanent arenas have a middle layer. For a grass arena or if the arena is watered using a subsurface system (for example, Ebb and Flood) then certain other construction principles apply for which more specialised design work is required.

Drawing: Elin Hernlund, Lars Roepstorff and Linda Eriksson

BASE LAYER AND DRAINAGE

With few exceptions, an arena has a foundation over the underlying soil, called base layer.

The purpose of the foundation is to provide a stable base for the arena. It should be sufficiently durable to remain uniform during use and maintenance of the surface. Depending on the design the base (or possibly the sub base at some times) can also contribute to dampening of the surface, which is generally considered to be desirable. The surface should resist damage with particular consideration for areas such as jump landing and where maintenance equipment comes into contact with the surface.

In addition to providing a base for the footing, the foundation also is critical to maintaining the proper moisture content in the surface. The principles vary depending on local climate conditions:

In dry climates/areas (also indoors) where drainage is not an issue clay or other materials that retain water can be used to keep a surface from drying quickly.

In wetter areas one purpose of the base layer is to promote drainage, provided the general construction principle is drainage through the arena as opposed to surface drainage. When an arena should be able to drain water vertically the base is responsible for quickly moving water into and out of the surface. Materials used for this purpose in the base layer include well graded road base, limestone and lava stone.

Therefore it is important that not only the design of the surface be considered when choosing the foundation, but it is also important to choose a foundation material which is appropriate for the local climate.

SEPARATIONS

Typically the top layers of the surface and the foundation are constructed so that they resist mixing over time. Blending can be caused by water saturation from rain draining through the layers, improper maintenance or loading from the traffic of horses over the material that causes a shift in the cushion. One common solution to keep the layers separated is by using a geotextile membrane. The geotextile membrane is designed to let water through but not sand grains. Depending on the mesh size anything from lay to coarse sand can be blocked from passing through the layer. Separation of the materials is important, especially between the base and the layer above to ensure that coarse material which can injure the horse is kept out of the cushion and to keep the finer material from the cushion from blocking the drainage system. However, the use of a geotextile membrane can present problems from two perspectives. Over time geotextiles will become clogged especially when the cushion layer has significant amounts of clay. The fine particles are washed down through the layers, so that the membrane loses its permeability and the arena then loses its ability to drain. If a shallow sand surface is used over the geotextile, perhaps 10 cm with a geotextile over the foundation, there is a risk that the geotextile will get get torn and can be pulled up even in normal use if the maintenance is not done in a way that keeps an even thickness of the top layer. The quality of geotextile is measured in thickness, and described as weight per square metre as well as by construction type and size of openings. It is typical to use at least a class 2 for a riding arena.

When a geotextile is not used it is also possible to build a separation from the foundation using a succession of smaller sand particles towards the top, for example, starting with 8-16 mm road base and finishing with 2-6 mm. Such a construction works because the finer particles filter through and are washed out with the drainage. For this to work the load from the horses must not create so much movement that the materials will be blended through a mechanical effect. This requires a relatively stable layer on top of the separation to prevent it mixing with the underlying material.

It is also possible to build an arena without a separation layer. These types of surfaces typically drain water from the top and not through the layers. This requires a convex top (camber) for the water to pour away. The primary concern is that proper maintenance must be done to ensure that the foundation materials are not mixed with the top layer. Like the other designs caution must be exercised in maintenance to both ensure a consistent footing and to keep from mixing the materials or damaging the foundation.

MIDDLE LAYER

The function of the middle layer is to have a bearing/stabilising and levelling effect, and preferably to provide good dampening of the maximum load from the horse. Such responsiveness or elasticity in the middle layer can be achieved in different ways, for example, by the use of coarse sand, controlled moisture in sand mixtures or elastic materials such as rubber or synthetic plastics. Over the next few years we expect to see developments and improvements in the construction and maintenance of this layer.

Some examples of construction of a middle layer:

- Road base (for example, 8-16), the thickness of the layer should be at least 3.5 times the greatest diameter of the particles.
- Shredded rubber (tyres), with a maximal diameter of 15 cm. It is important to consider environmental aspects of recycled rubber, and be aware that the rubber layer and the layers above it can tend to become unlevel. This can be controlled with careful maintenance.
- Mats of elastic material such as synthetic polymers.
- Lavastones.
- Crushed rock (stone dust), up to 15 cm deep. Stone dust can get compacted and become very hard, depending on the distribution of the size of particles.

Photo: Lavaletto

Imagine a recipe in a cookery book. The same recipe will produce different results on the plate, depending on the quality of the ingredients used and the skill and experience of the chef. The same is true for riding arenas.

◀ *If the top layer is planned to be thin, for example, less than 10 centimetres, this requires extra care at the installation and should in general be done with the aid of laser measurements.*

There are several other solutions for a middle layer that can work, but it is important to consider function and whether you can handle watering, drainage in outdoor arenas and access to water both indoors and outdoors when needed. Commercial products are marketed for use in middle layers, including mats of rubber or polymers that can provide cushioning and water control.

TOP/SURFACE LAYER

The top layer should provide the horse with an even and stable surface on which to work. The surface should allow the hoof a certain amount of glide at touchdown **(Read more in chapter 3 "The interaction between the hoof and the surface")** but still provide enough grip to maintain the confidence of the horse and rider. The top layer should reduce the shock at impact and the material should move just enough so that it can "gather" under the hoof when the horse moves on a circle, and thereby provide support to the whole hoof when the horse "angles" through a turn.

A range of materials are used as the top layer, but in general the main ingredient is sand. This can be mixed with organic materials such as woodchips or sawdust, or synthetic materials such as fibre, rubber or wax **(see also Chapter 5 "Construction materials")**.

Some construction examples:
The thickness of the top surface is not only determined by the demands of use but also by the existence of a middle layer. However in general the top layers are about 10 to 15 cm thick.

- Fibre-sand mixtures are often installed with a thickness of 10-15 cm.
- Sand-wood mixtures are often installed with a thickness of 10-15 cm, or thicker, obviously also dependent on whether there is a middle layer and what is beneath that.
- Waxed sand is often installed at a thickness of 10-12 cm.

When choosing the top layer, consider:
- What is the arena being used for?
- What maintenance is required?
- What is the local climate?
- Is the arena indoors or outdoors?
- What is the budget?

(Read more in Chapter 5 "Construction materials")

REMEMBER
Sand-wood mixtures often require being put down in stages, so that the material has time to settle, otherwise it can become too deep.

WATER CONTROL/DRAINAGE

Water control is important both to help keep the material moist and to allow drainage. Bad drainage will result in the surface being inconsistent for the horse to move on. A fast draining arena which is made of fibre sand or waxed sand will drain sufficiently well that the surface is effectively unaffected by water. Whatever the alternative, natural surface drainage or subsurface drainage pipes, the control of water in the surface is at least as important as the choice of material.

With deep drainage it is preferable to plan ahead for how the pipes can be cleaned, if and when they get blocked. This will be simplified if the pipes are placed in parallel with the length of the arena, with an access hole and pipes at ground level. This prevents being forced to dig up the pipes for cleaning at a later date. Placing the pipes in a zigzag pattern makes cleaning more difficult.

If natural drainage is used and the soil conditions are suitable, the ground must be even with some cross slope, typically less than 1% up to 2%. In some case the arena is designed with a camber (=highest in the middle, sloping to the sides) to achieve drainage. The design of an arena with a camber introduces the risk that the cushion depth will vary significantly through routine maintenance. This is because the harrow will tend to grade away the ridge of surface material in the middle. The possible thinning layer of surface material can cause changes in functional properties as well as blending of surface material and underlying layer material. This is less of an issue for an area with a simple cross fall across the surface, although attention must always be paid to the development of shallow areas.

It is possible to build systems where water from rain or daily usage is collected and can be recycled to return moisture to the arena. One solution for water control is the increasingly popular subsurface watering systems sometimes called "Ebb and Flood" system in which an arena consisting of sand or sand-fibre mixes basically lies over a pool of water. There are drainage pipes, in the bottom of the pool of water under the arena, that allow both removal and addition of water depending on whether you want to remove excess rain water or add water under dry conditions.

IN DEPTH

Why do clay and sandy soils work differently as riding surfaces? Clay has different forces than sand that hold the particles together. When soils with a significant quantity of clay is compacted with water and then allowed to dry out the particles will become very dense and hard and can even be difficult to break apart. When the moisture content is high and water fills the pores between the sand and clay particles, the surface can become very slick. Because of the unique properties of clay, in drier climates even a small amount of clay is critical to ensure that the surface remains lively and supportive for the horse. It still needs water control though.

Sand on the other hand, when dry, is only held together by the friction between particles. Depending on the specific size and type of sand, the water will be held within the pores when it gets moist. As water fills the spaces between the sand grains, forces of attraction exist between the mineral surfaces and the water which can bind the sand together. There is a minimum amount of water required to sufficiently fill the pores to hold the sand together, however if the particles are completely surrounded by water the space between the grains is lost and the water has the effect of a lubricant producing a deep and unsupportive surface. This balancing of water content is familiar to many beach goers who have experienced the sand both next to the water and in the dry sand farther from the water on the dry dunes. However, in between is a hard sandy stretch with an appropriate amount of water to support someone walking along the beach with less effort.

ARENA BUILDING SUGGESTIONS FOR THOSE SCRATCHING THEIR HEAD

- Contact stables/equestrisan centres in the area and ask if you can visit them. Ask for all possible information about how the arena functions, the construction and the contractor. Visit more than one establishment and compare the function with your own needs. Remember that natural sand is a finite resource, and that certain sand from a certain quarry may run out next month or next year. Also the properties of sand can vary within the same quarry. Knowing the typical design in your area is critical since the design has been adapted to local materials and is able to handle the local climate.
- If a certain arena seems worth copying, ask to be allowed to take samples from the top layer. Take at least 1000 grams from different parts of the arena, and order to carry out a sieve analysis.
- Use the result for a specification of your own order. Ask for tenders from quarries.
- Include details on transportation costs in the tender process. Transporting sand and other materials can be the costliest part of a sand order.
- Take samples of the delivered sand on arrival (again at least 1000 grams, from different parts of the delivery), to check that you received the product that was ordered.

Do not order sand without first determining a sieve profile **(read more in Chapter 5 "Sieve analysis")**. If your nearest quarry cannot deliver sand with the sieve profile you want, contact other contractors.

THREE EXAMPLES AND SUGGESTIONS

This guide clearly shows that it is impossible to produce a single universal recipe for an indoor or outdoor arena. How a riding arena will function is dependent on a number of circumstances, with the experience and skill of the person installing the arena being one deciding factor, together with the materials used and later maintenance. Due to geology, countries and regions within different countries vary in access to different types of sand. The selection of sand for an arena requires experience in evaluating sand samples that is too detailed to be covered in a guide of this format.

As a starting point for planning and selection three arena consultants list examples of different solutions, based on differences in needs and budgets. It is however not possible to give a complete set of instructions, as a specialist makes selections of sand based on experience and a comprehensive view of the arena. It is absolutely vital that the reader understands that the guidelines for sand and crushed rock given here are NOT sufficient to achieve guaranteed properties. The sorting, grain shape, grain mineral and fractions of silt and clay are aspects that help determine the function of the arena. If you, as a customer, have limited experience of sand and such evaluations it is important to enlist the aid of specialists with experience of sands and arenas. **Read more in Chapter 5 "Construction materials".**

A. Outdoor arena for a limited budget

ADVANTAGES AND DISADVANTAGES: Simple solution for a limited budget, on land and soil with natural drainage. Plan to water the arena so it does not get too hard, and careful maintenance so that the top layer stays even and level. This type of arena will probably have limited dampening/responsiveness and therefore not the first choice for jump training or competition at higher levels.

1. Base layer: level the soil, with some cambering (should be 0.7-1 % if no other drainage)
2. Separation: Use geotextile (minimum class 2). Purpose: prevents stones from the soil beneath "wandering" up into the top layer
3. Middle layer 1: 5 cm of road base 8-16
4. Middle layer 2: 2 cm of road base 4-8
5. Middle layer separation: 12 cm of crushed material 0-6
6. Top layer 8-10 centimetres, mixture of 50 percent natural sand 0-6 and 50 percent crushed material 0-6. At installation start by putting down a layer of 3-4 cm, let it settle and add as needed.

DESIGNER: Lars Bergström, Sweden

B. Outdoor/indoor at slightly higher cost

ADVANTAGES AND DISADVANTAGES: More thorough solution but more expensive. Needs planned watering to avoid getting too hard, and careful maintenance so that the top layer stays even and level.

1. Base layer with drainage and separation (geotextile minimum class 2)
2. Middle layer 1: 12-14 cm of coarse road base 16-32
3. Middle layer 2: 2 cm of fine road base 4-8
4. Middle layer separation: 12 cm of crushed material 0-6
5. Top layer outdoor arena 8-10 cm, mixture of 50 percent natural sand 0-6 and 50 percent crushed material 0-6. Top layer indoor 8-10 cm of sand 0-2. At installation start by putting down a layer of 3-4 cm, let it settle and add as needed.

DESIGNER: Lars Bergström, Sweden

C. Sand-fibre indoor arena

ADVANTAGES AND DISADVANTAGES: Arena that works for training and competition at higher levels with higher loads on the horse. Sand-fibre mixes are, in general, costly.

1. Base layer with drainage and geotextile
2. Middle layer: 16 cm of well graded road base material (8-16/10-18)
3. Top layer: 10-12 cm sand (0-1,5) (proportion of filler about 5%)* mixed with fibre/textile. **Read more in chapter 5 "Construction materials".**

DESIGNER: Oliver Hoberg, Germany

D. Sand-wood indoor arena

ADVANTAGES AND DISADVANTAGES: Budget friendly alternative that does not put maximum strains on the horse's legs and with correct maintenance will work well in riding schools and as well as for training/competition.

Base and middle layer: see example C
Top layer: sand/wood mixtures, **see Chapter 5 "Construction materials"**

DESIGNER: Karsten Koch

** The specifications of sand and crushed rock materials given in the examples are not detailed enough to guarantee certain properties. The final choice and selection of material requires practical experience.*

9

THE BUILDING PROCESS

A riding arena is a big investment and it is important that the building process runs correctly for the end result to meet expectations.

TO DO LIST

1. Review finances
2. Is the arena outdoors or indoors?
3. Set up a timeline for the project
4. Obtain the necessary permits
5. Investigate ground conditions and the soil
6. Consider site conditions including climate
7. What is the planned size of the arena?
8. Plan the surroundings of the arena
9. Is there water access? Plan for watering!
10. Have a tender process for the work, demand tenders
11. Final disposal of the material

TIMELINE

When planning an arena it is important to set up a timeline for the project, early on. It should describe what and when things should be done. The different steps are described below. An experienced contractor can help in several of the steps.

TIP
Plan to build or renovate an arena during the summer months. Then it is easier to have the use of other land for riding and avoid feeling pushed to make shortcuts to finish the work.

TENDERS

To control the end result and costs for an arena it is very important to include a tender process for the planned work. Tenders should then be reviewed, and references obtained from previous customers. If the customer is a local council, the project can require an official tender process with its own regulations. A tender must include specifications on arena size and materials **(see chapters 5 ”Construction materials” and 8 ”Construction principles”)**. A contract can have different scopes, each with drawbacks and advantages. A contract can also include preparations such as building permits and land testing. There are two main alternatives; a labour only contract with individual contracts for each single part of the installation, including drainage and digging, materials, putting the materials into place, and fencing. The other solution is a full contract, where you set functional demands. If you choose to make a contract with a prime contractor, a so-called general contract, they in turn have sub contractors and they coordinates their work. The drawback is that the total price is usually higher but on the other hand, the prime contractor takes responsibility for the coordination and can have his own beneficial contracts, for example, for materials. A contractor can also suggest alternative solutions that the customer was not aware of. A tender process can be divided into:

- **Implementation** (all planning is done before the tender)
- **Function** (final planning is done after the tender)

Function can, for example, concern the drainage system.

TIP
Many countries will have national Geological Institutes, with specialist knowledge on, for example, minerals and soils that can apply to riding arenas. One such organisation at EU level can be accessed through:

CLICK AND READ MORE

THE FOLLOWING POINTS MUST ALL HAVE BEEN FINISHED BEFORE THE CONSTRUCTION WORK ITSELF CAN START:

Permits

Before the arena is installed there are a number of necessary points that must be prepared and can take time. Contact the local council.

EXAMPLES: Are you planning to build in a built-up area with city planning, or in a rural area? Is the establishment classified as an agricultural business or not? Do you need building permits? Permission from neighbours? Is the site of possible archaeological interest and needs a test excavation?

Land and soil testing

Before the building plans progress further it is important to test and investigate the site based on type of soil and land. An experienced contractor with knowledge of geology is a suitable advisor. The findings can determine whether it is feasible to have a simple version of an arena **(see Chapter 8 ”Construction principles”)** or not. The drainage conditions are very important for the long term function of the arena surface!

QUESTIONS: Does the land have natural drainage or not? What is the location of the site? Does the site contain so called light soil? What in that case is the percentage of humus and clay? All light and clay soils including former bog land must have drainage installed! Clay soils can also have “water pockets”, beneath the surface.

Size

An outdoor arena should measure at least 60 x 24 metres if it will be used for Jumping.

Plan the surroundings

It is also important to design and plan the surrounding area of the arena, including access for arena maintenance. You need paths/roads to the arena for horses and maintenance equipment. The entrance to the arena itself should be at least 2.80 metres wide, to allow for machinery, and 1.50 metres for horses. The perimeter fence around an arena used for Jumping should be at least 1.20 metres high.

Water access

The access to and delivery of water must be calculated and planned before building starts. Moisture is a determining factor that directly affects the properties of an arena surface. No arena will meet expectations unless moisture is at the right level. The same arena, or other riding surface, can change properties completely depending on if it is dry, moist or very wet.

Many stables do not have sufficient water supply. In these cases it is important to consider solutions to improve water access, such as water tanks and/or dams for collection of surface water. Such plans should include contact with the local council in case permits are needed.

Laws and permits

Contact your local council to find out if and what laws and permits apply to the building of a riding arena.

Final disposal

The disposal rules for the arena surface at the end of its lifespan is an important point to consider in the choice of materials. As is mentioned in Chapter 6 and 7, there can be great differences in the cost of disposing natural materials such as a sand-wood mix, that can be put on your own or other agricultural land, compared to a surface mix containing synthetic materials such as fibre, that demands waste disposal handling with fees per ton. **(See also Chapter 6 ”Budget” and Chapter 7 ”Environment and substainability”).**

Photo: dizain.se

10 COMPETITION, MULTI-PURPOSE ARENAS AND PROBLEM SOLVING

Different disciplines can certainly share the same surface. But it is then important to understand how a surface can be modified with maintenance to address different demands.

THE CHAPTER IN BRIEF

If an arena is used for different activities and disciplines expectations can vary. Traditionally, Jumping and Dressage riders have had different demands, with Dressage riders wanting less impact hardness and less grip. Experience from international championships with both disciplines competing in parallel on the same surface has shown that riders from both can be satisfied, with the help of appropriate maintenance work. In addition experience shows that a surface with more impact hardness, as expected for Jumping competitions, gives the Dressage horse better traction in piaffe and passage.

Previous chapters describe arena solutions for stables/establishments with different demands and profiles. There are certain demands from some disciplines due to the horse affecting the surface in a certain way (and vice versa!). Maintenance measures can help you to modify an arena surface on a day-to-day basis by riding school horses, in a way that makes it suitable for a competition. But one issue is whether surface properties expected by competition riders for performance, such as high friction, increases the stress and strain on the horse's legs if used on a daily basis. There are research findings – albeit based on limited data – showing an association between use of sand-wood mixes (with less natural grip) and lower risk of losing training days due to injury **(Read more in Chapter 2 "What does research say?")**. Sand-wood meanwhile has a shorter "lifespan" than synthetic mixes, but is cheaper to install and less sensitive to manure compared to fibre and waxed sand materials. With the right maintenance a sand-wood surface can work also in competition, albeit not at the highest levels. Correct maintenance is however very important so that the material does not form "crusts" underneath the top layer, posing a serious risk for slipping (the arenas in the study with positive findings on sand-wood were private and in general well maintained and not aged).

The choice of top layer material for an arena at an equestrian establishment should be influenced by a combination of finances, resources for maintenance and any plans to hold competitions **(see Chapter 5 "Construction materials" and 9 "The Building Process")**.

What should you do if you need to be able to use an arena for more than one purpose?

MAINTENANCE AND COMPETITION

As seen before the same surface can vary in its properties with different maintenance (or lack of!). Competition surfaces, especially at higher levels, demand slightly different properties to training surfaces. Preliminary results from a recent FEI competition surface study have shown that riders at international top level competition value firm surfaces, with impact firmness, cushioning, good responsiveness and good grip (which potentially increase the load on a horse's leg). One recurrent observation is that many riders expect such properties with performance in view, but choose to train on other surfaces (with less firmness and less grip). This potential contradiction is mentioned in the beginning of this guide; the balance between performance and risk of injury.

PLANNING FOR COMPETITIONS

In advance

A good general maintenance plan is the first step for someone who wants to use an arena for more than one purpose, with different demands or expectations.

If you run a riding school where the arena is sometimes used for competitions, your day-to-day maintenance will influence how early you need to prepare to adjust to competition demands. A well-maintained arena with, for example, a good moisture level will require less preparation specifically for the event. Modifying your maintenance for competition will allow you to have the best possible preparation and provide consistency during the competition despite increases in traffic.

One vital point is to check before a competition (and at any time) that the arena does not have a hard "crust" beneath the surface, which is especially relevant for traditional sand-wood surfaces, but at a lesser extent can occur also with synthetic arenas. This poses serious risk of horses slipping. Such "crusts" can be eliminated through deep harrowing **(Read more in Chapter 11 "Maintenance equipment" about sand wood and harrows, or equivalent in synthetic surfaces)**, but that must be done in advance of the competition.

One example is watering, which for some arenas can need to be adjusted at least a week in advance of the competition event, if not correctly watered at other times. Rolling should not be necessary at a well-maintained permanent arena.

On the day

On the day of competition it is important to keep the surface uniform to meet riders' expectations (and potentially prevent injury). This must be achieved with little yet sufficient maintenance during the class. With up to 40 starters in a Jumping class the surface can be raked by hand between horses. Classes with more than 40 starters should have intervals of 10-20 minutes to allow for further raking or the use of a tractor, in order to ensure consistent properties of the surface for all participants. This can be a major challenge in classes at lower levels with very high numbers of participants in one class.

One advantage with fibre/waxed sand materials in competitions is that they maintain more consistent properties through a whole class, compared to traditional surfaces.

Experiences from competitions in Sweden have shown that even with a professionally installed commercial surface, correct maintenance during the competition is very important to satisfy riders demands.

Temporary surfaces

Plenty of competitions, especially at international level, are held on temporary surfaces at multisport/event venues. This involves very different building principles compared to a normal riding arena. For a start it is not possible to make several layers, with the exception of using rubber mats or similar. The greatest challenge lies in getting the surface to "settle" in time. Normally this process requires weeks or months. At temporary venues they must be rideable after one to three days. Mechanical arena testing indicates that the surface settles day by day as the show progresses, and would not be suitable for permanent use.

Experience shows that the same arena surface can be modified to satisfy demands both for competition and training, with maintenance such as watering and rolling for competition and then "loosening" the surface, to make it less hard for training.

Discipline-specific expectations

The same principle applies to modify the surface for Jumping versus Dressage. Traditionally, Jumping and Dressage riders have slightly different expectations and demands of a surface. Experience from international events including championships such as the Olympics or World Cup Finals with Dressage and Jumping held in parallel show that the two disciplines can share the same arena.

Traditionally, Jumping riders expect a surface with more impact hardness. This is achieved mainly through rolling the surface and increasing moisture content by more watering, started a few days before the event so that all layers of the surface become thoroughly moist.

Dressage riders traditionally want a looser (softer) top layer. This can be achieved by harrowing/dragging of the superficial layer.

COMMON FAULTS AND SUGGESTED SOLUTIONS

Hard outdoor arena

ACTION: Add natural sand without filler, that is washed sand, so that the filler fraction decreases **(see Chapter 5 "Construction materials")**. Put down 1-2 cm, and mix with the rest of the surface layer. Order: (washed) 0.1-2 gravel/sand outdoor, (washed) 0.1-2 sand indoor.

Hard track (the rectangle along the fence/wall):

ACTION: Regular (once a week) deep harrowing of the track itself (if sand-wood).

Dusty outdoor arena

ACTION: Watering Use a water tank or preferably install automatic sprinklers. There are different opinions on adding salt (mixed into the top layer, not left on the surface). On an outdoor arena the salt over time can block the separation layers and affect drainage. Indoor that is not an issue.

Loose/deep indoor surface

ACTION:

1. If the top layer is thick; remove some top layer material with the aid of a road grader.
2. Add fibre **(Read more in Chapter 5 "Choice of sand for fibre surfaces")**

Unlevel/uneven arena

The top layer is unlevel, for example, 4 cm thick at one end and 15 cm in another.

ACTION:

1. Level it with the aid of a road grader.
2. Review maintenance regime.

TEST

If you want to make changes in an arena by, for example, adding a different material but are unsure about the effects, one solution is to make a "test area". Mark an area of, for example, 10x10 metres and do the changes there, ride on it and feel the result. If the results meet your expectations the next step is simply to make the same changes across the whole arena. If you feel it did not work out you simply spread the material from the test area across the whole arena so that it gets diluted, and the negative effect is limited.

Oliver Hoberg

Course builders in Jumping must familiarise themselves with the arena in advance, and determine any quirks such as an area with less grip or other inconsistences. This should then be taken into account in the way the course is laid!

Photo: Mikael Sjöberg

11

MAINTENANCE AND RENOVATIONS

Correct maintenance is essential for arenas to function and meet expectations.

Photo: Mats Molén

THE CHAPTER IN BRIEF

Correct maintenance is essential for arenas to function and meet expectations. Here is a checklist for the most important aspects. All points are discussed in more detail later in the chapter:

- **SKILLED ARENA STAFF** – assign responsibility for arena maintenance to one-two persons in the yard and give them the chance to develop experience
- **SUITABLE MACHINERY** – different top layer materials require different equipment
- **REGULAR AND FREQUENT MAINTENANCE** – daily for optimum results
- **SUITABLE AND EVEN APPLICATION OF MOISTURE** – good access to water (for irrigation) is very important for arena maintenance
- **AVOID MANURE CONTAMINATION** – or be prepared to replace the top layer much more frequently
- **ANNUAL RENOVATION**

Photo: Roland Thunholm

IT IS IMPORTANT TO VISUALISE THE MAINTENANCE AIMS

- **Keep an even distribution of the top layer across the whole arena,** to avoid thicker or thinner areas or with hollows in some places and mounds in others.

  WHY? Otherwise the surface properties will be inconsistent, which has an adverse effect on performance and has the potential to increase injury risk.

- **Maintain the mixture of different materials in the top layer** so that, for example, loose fibres do not collect on the top of the surface in a sand-fibre arena.

  WHY? If the materials get separated the surface loses the intended properties.

- **Prevent compacting of the top layer,** especially on the track or at the entrance.

  WHY? A common problem in older or badly maintained surfaces is that a hard "crust" of compacted material has formed below the top layer. Such a crust can reduce traction and grip, which will increase the risk of horses slipping and falling. Compaction also increases impact hardness, which has been shown to increase injury risk. Crusts can be prevented by appropriate maintenance regimes.

- **Maintain correct and consistent moisture.**

  WHY? The properties of a surface change substantially depending how dry or wet it is. A dry surface is harder/deeper, making it more taxing for the horse, and creates dust, which can affect the airways of horses, riders and trainers/coaches.

What should you also keep in mind?

- **Protect the deeper layers** so that the geotextile layer is not damaged.

  WHY? Stones from the base beneath can "creep" to the top, creating an injury risk. If the geotextile layer is damaged or disturbed it can crease into folds. This poses a serious risk of accidents, if a hoof gets caught in the folded material.

- **Keep the arena free from manure!** This is a strong recommendation from many commercial producers of fibre-sand/waxed surfaces, but it is also very relevant for traditional arenas with sand-wood mixtures. To be really thorough you should also make sure that tractor tyres and horses' hoofs are clean when entering the arena.

  WHY? Manure that gets blended into the top layer affects the properties of an arena and will shorten its useable lifetime. One undesirable effect of manure is to decrease grip and traction. In waxed sand arenas, manure can cause the wax to dry out. Manure left on a surface can also affect air quality for horses and humans and cause bacterial growth, especially in warmer climates.

In conclusion maintenance affects all surface properties and characteristics that are described in chapter 5 "Construction materials":

- Impact firmness, cushioning and responsiveness
- Grip
- Uniformity and consistency over time

WHAT DOES SCIENCE SAY?
Biomechanical testing by the equestrian surface researchers have demonstrated that the properties of a certain competition arena will change and can improve from one day to the next according to the maintenance measures. Studies of Thoroughbred racehorse have found that and the intensity of use and frequency of racecourse maintenance procedures affect the risk of serious injury, including catastrophic fractures. Here are short summarys of two scientific papers concerning maintenance and surface properties:

CLICK AND READ MORE

CLICK AND READ MORE

PLEASE NOTE: The maintenance strategies described here are aimed at keeping the arena in the best possible condition. Compromises based on (lack of) finances or time will also mean compromises regarding the properties of the surface, the length of use and potentiallythe soundness of horses using it.

The "lifetime" of an arena (with acceptable function) can vary from three to 20 years, depending on the choice of materials, wear and maintenance. Arenas need both regular maintenance and occasional more thorough renovations. Maintenance-free arenas do not exist.

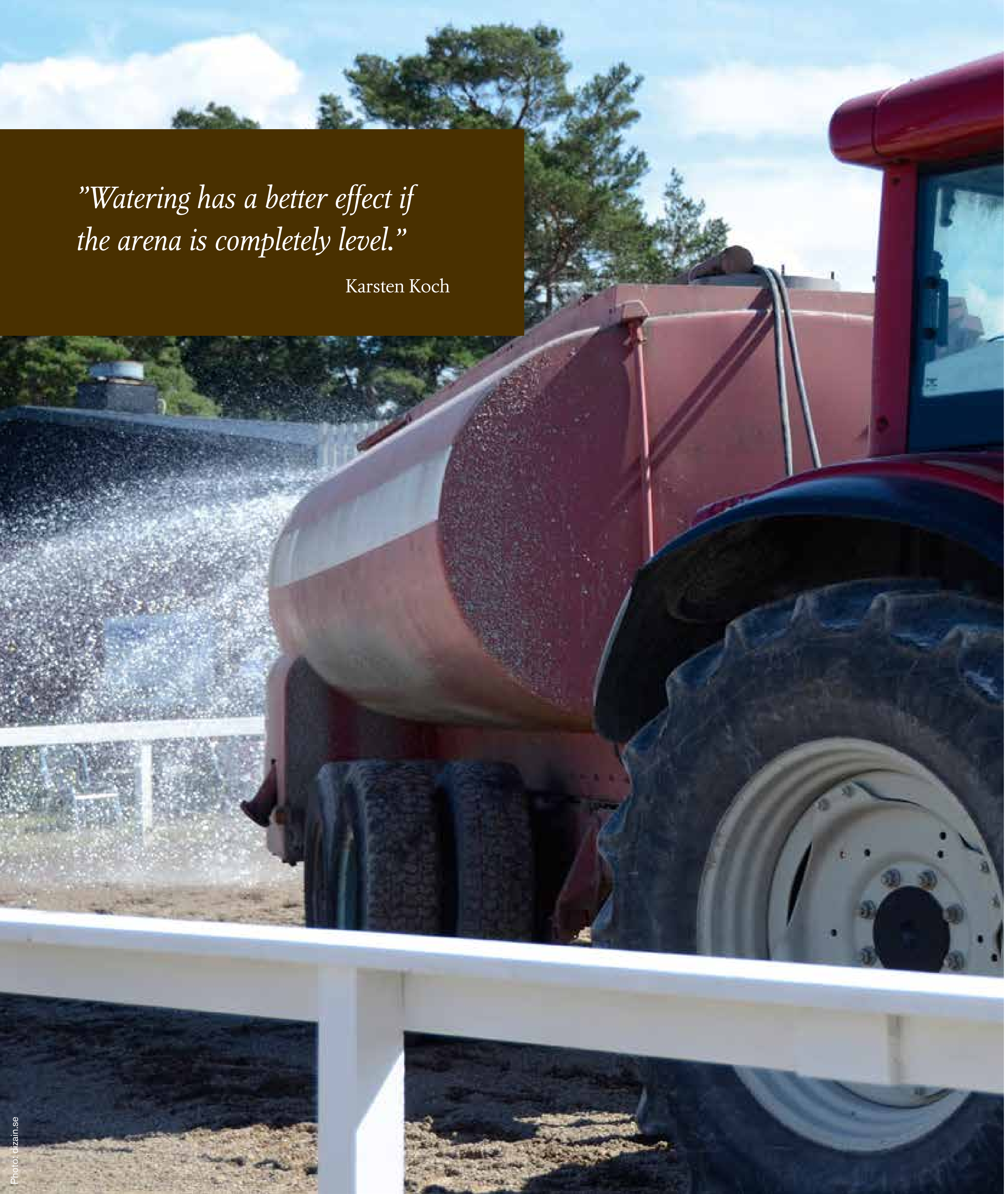
Remember also:

- Do not use the arena as a paddock/turnout area, leaving the horse without supervision. A horse turned loose in an arena increases the risk of contamination from manure and other organic materials, and may cause the top layer to become unlevel. Of course the horse can be let loose for a few minutes to have a quick roll or a canter, but this should be followed by maintenance.

- Lunging with the person standing in one place is a common cause for the top layer to become uneven, and should therefore be avoided. Vary activities across the arena, so that not everybody rides along the track, fences are not always in the same place or horses being lunged are not always lunged in the same spot.

- Outdoor and indoor riding arenas have different needs and conditions. Watering is one example; a heated indoor arena will have greater evaporation of moisture than an unheated one, which may need to be rectified by watering

An important aspect of arena maintenance is to learn to "read" the surface and notice how the top layer is distributed, so that mounds and hollows get evened out. A maintenance person/arena worker should also keep a dialogue with the riders using it.



”Watering has a better effect if the arena is completely level.”

Karsten Koch

Photo: dizain.se

ARENA STAFF

It is very important that maintenance work is done by persons who either have good experience, or are given good training. The more experience the arena person has, the more he or she will notice and adjust irregularities in the arena surface. It is also very important that the arena person has sufficient time set aside for the work!

A yard/stable dependent on volunteer work should appoint one or two persons with a natural interest in arena work to take responsibility for the condition of the arena and to maintain it continuously. The same applies for yards/stables with paid staff.

TIP
Practice studying hoof prints, as a reflection of surface properties. How deep has the hoof gone into the surface? Is it a clear imprint or hardly detectable and did the hoof slide across or into the surface? Also watch how horses move on a surface.

WATERING

As discussed in chapter 5 on materials access to, and distribution of, water are important. This can be achieved using a variety of different systems:

- Ceiling sprinklers
- Wall sprinklers
- Water trucks
- Moveable sprinklers
- Waterhoses

For watering to have the intended effect it is very important that the water is evenly distributed throughout the arena. If some parts of the arena get wetter than others this will cause inconsistencies and unevenness that is suspected to have a negative effect on the horse and its performance. It is difficult to provide an even distribution of the water without watering from the ceiling.

In other words, moisture should be equally distributed in the surface. Especially outdoors, it is important to analyse differences in evaporation at different sites in the arena. Are some areas always in the shade, while others are lit by the sun? This probably means that the sunny spot dries quicker, while the shaded spot stays wet

”Practice feeling the sand in the arena! I use my hands as “testers” and it is interesting to compare what I feel with the results of biomechanical testing by the ”mechanical hoof”; what I feel and the test equipment registers usually match well.”

Oliver Hoberg

or moist. The arena surface will then be inconsistent, with variations in its properties. There are sprinkler systems with timers that can control and vary the distribution of water across the arena to compensate for shade/sun. Watering is an art and as with the rest of the maintenance programme, should have one or two experienced people consistently in charge. There is less need to water waxed sand materials compared to other materials.

Watering in a cold climate

Watering in a climate with temperatures below freezing is difficult to undertake due to the risk of the surface freezing when water is added. One suggestion is to prepare early by planned watering during autumn, so that the surface layers are thoroughly moist in advance of the freezing temperatures and add salt to prevent freezing (see the section on salt).

MAINTENANCE EQUIPMENT

It is important to include maintenance equipment in the calculations when budgeting for a certain type of arena. Arenas with traditional surfaces such as sand-wood mixtures can be maintained with traditional farming equipment. Fibre and waxed sand surfaces require special equipment, which is more expensive than the corresponding farming machinery.

If you buy or have bought a ”ready-made” arena it is important to request advice and information on maintenance from the producer. This should include machinery (type of tractor, harrow or drag, and also the type of tractor tyres), how and how often maintenance should be done, watering and possibly the use of salts. However not all contractors/producers offer well thought out maintenance plans.

REMEMBER
It is important to consider the tractor tyres. Oliver Hoberg advices that standard farm tractor tyres are too harsh for a riding arena as they create pressure that is too high and too uneven. As long as you drive straight ahead there is no real problem, but when turning these tyres push sand to the outside. One compromise is to choose so-called turf tyres that do not have such a heavy tread pattern. (A cheaper and unconventional alternative suggested by a different consultant is to use worn tyres with less tread!)

Machinery for sand-wood:

1. **Tractor, light farm type**
   It is important that the tractor has an adjustable hydraulic arm/lever, to adjust the height of the harrow. Daily dragging and harrowing can be done using a quad bike or car to pull the harrow which will smooth the surface top, but without a hydraulic arm it is not possible to create pressure to redistribute the surface material. A "wave" effect can be caused by a lack of material re-distribution. A tractor is required for deep harrowing, which is also an important part of arena maintenance.

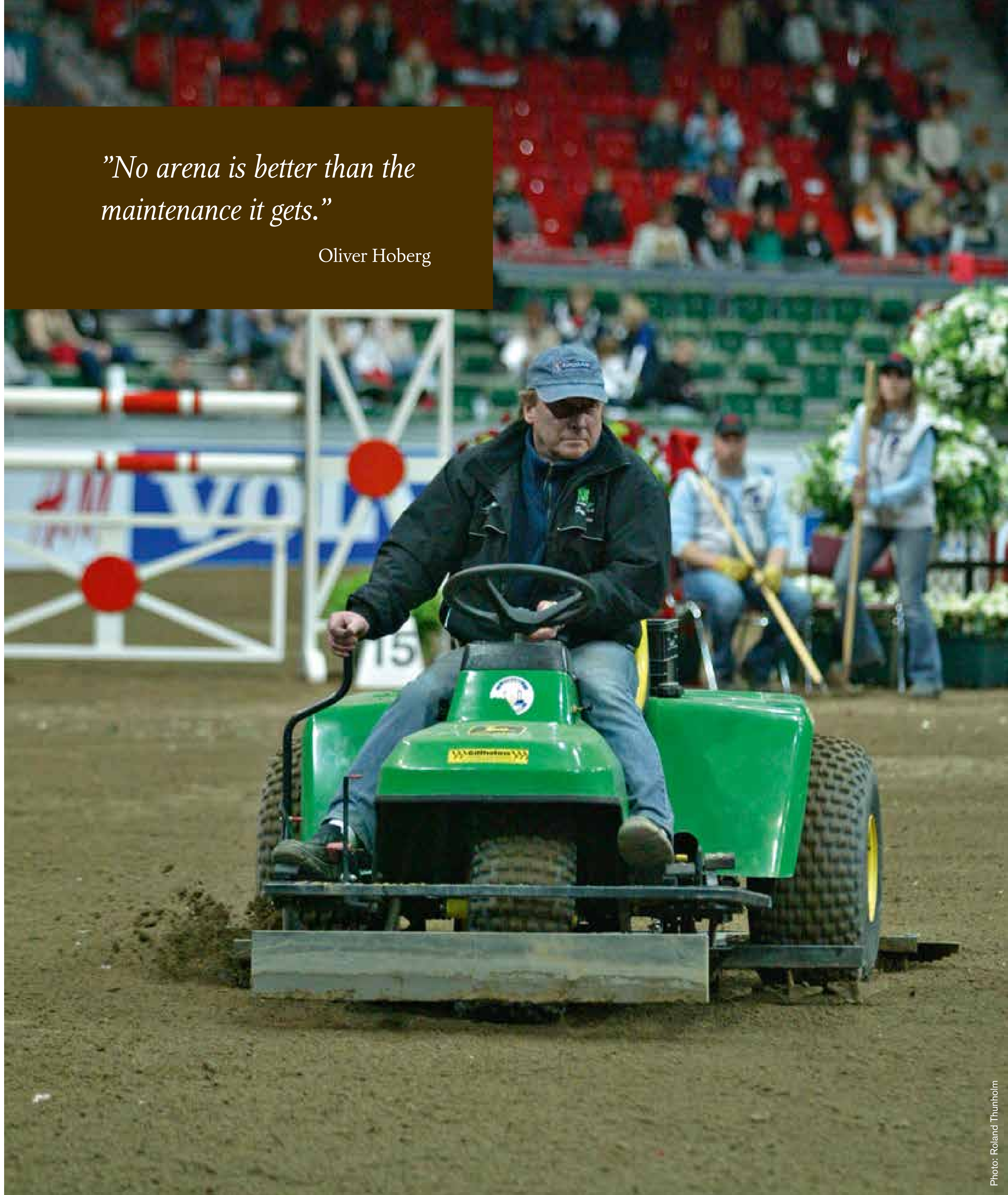
2. **Drags**
   Drags like harrows are available in different models. One simple version is a steel wire net. The wire needs to have a diameter of at least 8 millimeters to be strong enough. The wire net should also be steel re-enforced (stiffer) at the back and front edges, otherwise it is likely to be bent into a hammock shape. The drawback with this simple solution is that it only smoothes the superficial layer. Farming drags are required for a more thorough effect.

3. **Harrows**
   For traditional sand-wood mixtures regular harrowing is important. Rigid tine harrows and sprung harrows are the two main types. Opinions differ as to which type is preferable for riding surfaces. One argument for rigid tines is that they can be used for deep harrowing, which is important with sand-wood mixes.

   WHAT IS DEEP HARROWING? Deep harrowing means working through the layers of the top surface to break up the "crusts" of compacted material that may have formed just beneath the top. It is important to firstly measure the depth of the top layer and then adjust the height of the tines accordingly. They should reach as deep as the layer is thick, but not disturb the separation layer.

HARROWING TIP
It is important that the outside track is harrowed. Normally the harrow is a bit wider than the tractor, and if you drive in an elliptical pattern you will reach all the way out to the edge. But you can also use the hydraulic arm to angle the harrow down on the outside edge then the harrow will have more effect.

Lars Bergström



"No arena is better than the maintenance it gets."

Oliver Hoberg

Photo: Roland Thunholm

Photo: Svenska Ridsportförbundet

◀ *A traditional arena needs deep harrowing in order to break up compacted material. This means that it is important to build the arena so that a tractor and a harrow can get in and out. If the arena is only accessible for a quad bike deep harrowing is impossible!*

Machinery for fibre/wax

Fibre-sand and waxed sand surfaces require a combination of harrows and drags, which are available in about 4-5 different models. They can be towed by a quad bike or special light tractor. An advantage with these surface-specific machines is that they can be adjusted for depth so that the surface material is worked at different levels.

IMPORTANT
A farm harrow is not suitable for maintenance of fibre sand or waxed sands! (see below)

MAINTENANCE PLANS

Maintenance needs to be planned. Here we give suggestions about frequency and technique, but the needs of the arena will, of course, be influenced by how often it is used and how it is used. The experts also give individual suggestions.

REMEMBER
The number of horses using the arena in a day is not the only criteria for maintenance. The type of activity is also important; a few horses in a Jumping session can be enough for the material to become uneven and need adjustment. The age of the surface is also be a factor; an older surface might need more attention.

Annually

Plan to relevel the arena annually with a road grader, to keep the material evenly distributed and prevent "waves" in the top layer. This can be combined with laser beam testing to fine tune the levelling. It is important to realise that an arena with areas of compacted material or "crusting" beneath can be level on top, but still not consistent, if the crusts and compaction are left untouched. This can be prevented by deep harrowing before the road grader.

Wood products (woodchips, sawdust) decay over time. Remember also that the sand in the top layer irrespective of good maintenance will be subject to mechanical wear, as the hoof acts like a "grinder". How quickly this occurs is also dependent on the sand

TIP
Using a road grader on the arena to (re)distribute the material and get it even is a good option. But if you have an arena with areas of very compacted material beneath the surface the most efficient solution is to scrape off the entire top layer, work it through to loosen in the compacted areas, and then redistribute the material.

Oliver Hoberg

mineral **(see Chapter 5 "Construction materials")**. This means that over time fractions of the sand turns into dust, or more "filler" **(see Chapter 5 "Construction materials")**. The arena will then become more compacted, and the fine grains of the "filler" can clog the drainage and geotextile layers. Regular and correct harrowing helps prevent the filler material from "drifting" downwards through the arena layers. Some sand is also lost when removing manure. It is therefore advisable to do regular top-ups with new material, and scrape it off at longer intervals. This is also an opportunity to check on the road base beneath the top layer, and the drainage.

Every week/day

MOST IMPORTANT: Keep a suitable degree of moisture (with the help of sprinklers). An outdoor arena should be watered every day in dry weather. (Watering systems have their own section in this chapter).

OUTDOOR:
Expert A: Daily maintenance!
Irrespective of the number of horses using it.
Expert B: Adjust the frequency of maintenance to the frequency of use:
10 horses/day:
Sand-wood: Daily dragging, deep harrowing once a week.
Fibre/wax: daily dragging with special equipment (do not deep harrow!).

INDOOR:
Expert A: Daily maintenance if it is used by about 20 horses or more. If the daily horse number is around 5, every third day can be sufficient.
30 horses/day:
Sand-wood: Daily dragging, deep harrow twice a week
Fibre/waxed sand: Daily dragging with special machinery (do not deep harrow!)

HOW TO

Arena maintenance is a question of experience and individual talent. Here is some advice about equipment use:

Dragging

When dragging it is important not to drive too fast or too slowly. The material should move smoothly in the drag. If you drive too slowly it will gather at the front. If you drive too fast the material is thrown about and gets uneven.

PATTERN: Alternate between driving clock-wise and anti-clockwise. Start an elliptic oval from one short end and continue the pattern across the whole arena. Next do a rectangle along the long side to the middle of the arena, and repeat this rectangle sideways until you are on the other side. An alternative is a round wrap-over pattern so a version of the ellipsis but rounder that includes the edge along the fence or wall.

Harrowing

SUGGESTIONS for deep harrowing: Alternate between driving clockwise and anti-clockwise. The tines should be making lines in the stonedust (or other) layer beneath the surface, but it is just as important that the geotextile layer is not damaged or moved. Adjust the tines based on how deep the top layer is.

SALT

As with other materials "salt" comes in different versions, for example, sodium chloride and calcium chloride. You use salts for different purposes; to bind dust and decrease the need for watering, or to prevent the arena from freezing. Salts can affect the arena and surface properties, in addition to their effects of binding moisture and lowering the freezing point.

There are suspicions/experience that the salt can create crystals that clog the arena drainage. The amount of salt is also an important consideration. Outdoors it can affect drainage, and be rinsed out. Both outdoors and indoors the salt can help "bind" the layers of the surface and make it harder. Does the salt pose any risk for horses? We do not know for sure, but it can probably cause skin irritation if the horse has small scratches, including from clipping. (Small animals running on the arena may have irritation of their paws).

How often?

SUGGESTION (in a cold climate): Indoors put down salt about 2-3 times a year, for example, in the autumn combined with watering, in preparation for freezing temperatures later.

AMOUNT: Outdoors depending on weather conditions; 0.5-1 kg per square metre is one suggestion (or 800 kilo in a riding arena measuring 20x60 metres). Another guideline indoors is to use magnesium chloride at maximum 125 gram per square metre. (Magnesium salt has the advantage of being less corrosive to equipment and machinery).

PREPARATION: When putting down salt it is very important to use a harrow or other equipment to mix the salt thoroughly with the rest of the material, so that it does not stay on top.

REMEMBER
An important aspect of arena maintenance is to learn to "read" the surface and notice how the top layer is distributed, so that mounds and hollows get evened out. A maintenance person/arena worker should also keep a dialogue with the riders using it.

Photo: Jessica Ortiz Bergström

12 FUNCTIONAL TESTING

How a human and a horse experience a surface will differ greatly. But mechanical testing has been developed to give objective testing of arenas.

THE CHAPTER IN BRIEF

- How does your arena function?
- What expectations should you have of an arena that you are planning to build?
- What feel will you and your horse get from the arena surface at your next competition?

It is obviously the arena function that is important. But can you measure that, and how ?
There are several tests to test, for example, roads or evaluate soccer pitches, but such equipment is not relevant for a riding arena. The response from the surface will be different when a horse is moving on it compared to if a soccer player is running. As is pointed out in Chapter 4 it is impossible for a person to "test" how a surface affects the horse by, for example, jumping up and down on the ground. **(Read more in Chapter 4 "Arenas, their function and properties")**.

How a riding surface responds to the load from the horse is important and to be able to measure it by mechanical means is equally important, in order to understand what effects the surface has on the horse. As described in previous chapters the properties of an arena are determined not only by the choice of materials but also construction, age, maintenance and moisture, from either rain or watering. Scientific testing of arenas has demonstrated that:

- Two arenas with different top layer materials can have very similar properties
- Two arenas with what looks as the same top layer can differ greatly in how they affect the horse

How a horse experiences the function of the surface, and the resulting loads exerted on their limbs during training and competition on the arena is crucial for soundness and performance. There are plenty of mechanical tests for evaluating, for example, a soccer pitch or a road, but these tests are of little use on a riding arena because the response from the surface is different when the load is applied by a moving horse. As mentioned in chapter 4 regarding the functional properties of an arena, it is impossible for a human to evaluate how an arena affects the horse by, for example, jumping up and down on the spot.

Arena testing for both soccer and equestrian sport can be done by using the athlete (human or horse) to make measurements. To do this sensors that register forces or vibrations are attached to the leg and foot or hoof. Recordings are made each time the hoof makes contact with the ground. The advantage of this type of testing is that what you measure corresponds with what the athlete experiences, which provides information about potential performance benefits and injury risks. The drawback is that the measurements are influenced by the individuals themselves, which makes it difficult to get exact comparisons between arenas, unless the same individual is tested each time. Tests should be carried out with equipment that is standardised and validated. There are also a number of testing machines in which sensors such as accelerometers or force metres register a response from a surface. In order to obtain relevant information about functional properties any testing machine for equine surfaces must mimic the loading conditions of a horse taking into account weight and speed.

CLICK AND READ MORE
(scientific White Paper)

THE ORONO BIOMECHANICAL SURFACE TESTER

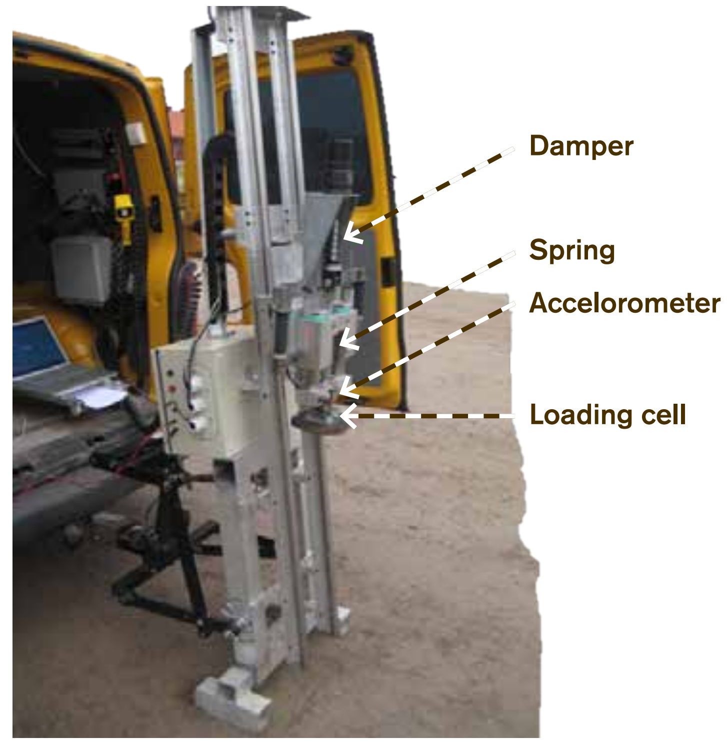
The Orono Biomechanical Surface Tester was developed for use on Thoroughbred racecourses in the United States, and then adjusted for equestrian riding surfaces at SLU in Uppsala. It is often called "the mechanical hoof", as by dropping a hoof shaped projectile at an angle to the ground it mimics the impact of the horse's hoof on the surface. The machine is mounted to a truck or van of sufficient weight and is supported by a frame, which is placed on the ground for stability during testing.

The metal "hoof" is mounted beneath a heavy weight, which is dropped to the ground between two guide rails. When the weight is released, the mechanical hoof first hits the ground at a specific angle which has been determined based on measurement from high-speed motion capture of horses' legs. Thus the mechanical hoof mimics the motion of the forelimb of a horse during the early landing/touchdown phase, as a simultaneous downward motion and forward slide of the 'hoof' occurs when it contacts the ground. An accelerometer mounted on the metal hoof measures the surface hardness. A load cell measures the impact of the heavy weight as it loads the 'hoof' to a maximum in both the vertical and horizontal directions. This, in combination with position sensors on the hoof, measures the cushioning of the surface during the loading phase, the amount of grip and the surface responsiveness. For testing of equestrian surfaces the mechanical hoof of the machine has been set to mimic that of a medium-sized Warmblood horse.

COMPETITION ARENA TESTING

Tests with the mechanical hoof described above are not commercially available at this stage, but the Fédération Equestre Internationale (FEI) is considering it as the standard for testing arena surfaces at major competitions, including championships such as the World Championships or the Olympic equestrian events.

During competition, the horse performs high intensity work resulting in high loads on the bones, joints and tendons/ligaments. Preparation for competition not only requires the horse and rider to have the necessary technical skills, but also the horse's bones, joints and tendon/ligaments must be adapted sufficiently to withstand the loads experienced during competition **(more about adaptation to training in Chapter 2)**. Individual horses adjust differently to specific surfaces. One aim of surface testing at competition venues is to inform riders what characteristics and properties to expect, in order to decide whether the surface properties at a certain competition are suitable for a specific horse, and/or let the horse train and thus adapt on equivalent surfaces. Hopefully in the future competition surfaces at medium and lower levels will also be tested. The competitor will then have the opportunity to learn about the arena surface properties expected at specific shows before entering, and based on that information decide if his/her horse is suitably prepared to compete on that surface.



▲ *The Orono Biomechanical Surface Tester simulate the impact of a horse's leg on the ground. The machine is mounted at the back of a van or truck of sufficient weight, for ease of transport between and on arenas, and is supported by a frame, which is placed on the ground for stability during testing.*

▲ *The metal "hoof" is mounted beneath a heavy weight, which is dropped to the ground between two guide rails. The rails have different angles, which mimics the motion of the early landing/touchdown phase, as a simultaneous downward motion and forward slide of the 'hoof' occurs when it contacts the ground.*

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