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SAFE

The Foundation for Safer Athletic Fields

Field Hardness Testing

The most important element of a sports turf manager's job is to provide the safest fields for athletes, regardless of the level of play. Across the country there is heightened focus on athlete safety which has resulted in increased scrutiny of all potential contributors to athlete injury. Players on any athletic field are exposed to some risk of injury; however, reducing head injuries is a major concern, especially for football leagues. Most concussions are the result of athlete-to-athlete collisions; however, approximately 10-15% of concussions in American football are caused by head-to-surface contact. When a player falls on a field, the impact is absorbed by the playing surface and the player's body. The "harder" the surface, the greater amount of impact is absorbed by the player's body, and therefore, the greater the probability a fall will result in serious injury. A properly maintained playing surface can help reduce injury risk. Whether natural or synthetic turf, field management practices directly affect field hardness.

What causes field surface hardness?

Natural Grass Fields

Field hardness is dependent on the percentages of sand, silt, and clay that make up the rootzone. Native soil that is made up of high clay content is going to be firmer than a predominantly sandy soil at the same moisture levels. Soil that is predominantly sand typically provides a softer surface. However, attention must be paid to the size range distribution of sand particle sizes. Soil that is uniform in large sand particle sizes can create unstable playing surfaces. Conversely, when soil is made up of a wide range of particle sizes, finer particles fill up the large pore spaces between coarser particles and essentially clog up the turfgrass rootzone and contribute to compaction. Conduct research and check with your local university to determine the particle size distribution that will work best for your sports field.

Compaction of athletic surfaces results in a surface becoming increasingly hard. Compaction is a reduction of air space amongst particles of gravel, sand, silt or clay. Levels of compaction tend to increase as soils become heavier with more silt and clay or if soils are made up of a wide range of particle sizes. Compaction can be the result of traffic or even something as simple as heavy rainfall. Elements contributing to compaction include weight, duration, and frequency. This can be envisioned more clearly with a marching band practicing on a field. The band member provides the weight; marching along lines or in place provides the duration (length of band practice in time) and frequency (the number of times the ground is pounded by marching). Moisture in the soil or base of the field from rainfall or irrigation serves as a lubricant allowing particles to slip together, reducing air space and forming a compaction layer. Keep in mind that a compaction layer only forms to a weight-bearing depth on the surface that is capable of holding the weight responsible for the compaction.

On natural grass fields, the amount of water in the soil influences surface hardness. Under dry conditions, the surface will be harder. When soil moisture is adequate or excessive, fields will be softer. Increased use of a field with heavy soils and moisture leads to increased potential for compacted soil. When the field dries in combination with a compacted surface, the playing surface becomes very hard. In addition, lack of turfgrass cover can also contribute to field hardness.

Field Hardness Testing

Synthetic Turf Fields

On synthetic turf fields, compaction is not a major cause of increased surface hardness. Due to the uniform size of infill particles, compaction is limited. However, when infill is composed of both sand and rubber, separation and settling of the sand component can form a compaction layer between the backing and the rubber infill. The rubber infill material is used to provide cushioning, and more infill means more cushioning. Higher surface hardness levels are almost always associated with low infill levels. Low infill levels are a result of the crumb rubber being removed from the field over time by athletes and equipment or migrating to other parts of the field during heavy rain events. Although the small amount that ends up in athlete cleats or on equipment tires may seem insignificant, over time it adds up. Removal of the infill is most evident in high use areas, such as goal mouths or between the hashes in football.

How is field hardness tested?

Monitoring field hardness is key. Most high schools do not test the safety and durability of their athletic fields on a regular basis, which could put athletes at greater risk for concussions. The NFL now requires both natural and synthetic fields to be tested and certified before every game using a set of "recommended practices." Recommended practices include tests such as field hardness (Gmax), soil moisture, infill depth, and visual inspections, depending on the surface type.

Surface hardness is measured by dropping a weight (referred to as a missile) from a fixed height onto the playing surface. The missile contains an accelerometer that measures how fast the missile stops once it hits the surface. A numerical value, referred to as Gmax, is then generated. A high Gmax value means the missile stopped quickly and there is less absorption of force by the athletic surface and more absorption of force by the athlete, which indicates the surface is hard.

Both natural turfgrass and synthetic turf fields can be tested using a Clegg Impact Tester or F355 device. Gmax values taken from each of these devices are not interchangeable because the missiles are different weights and are not dropped from the same height. In other words, 100 Gmax measured with the Clegg is not the same as 100 Gmax measured with the F355. However, research conducted by Penn State indicates a high correlation between the two devices.

The NFL field testing program requires playing surface hardness of both natural and synthetic turf fields to be measured with the Clegg Impact Tester. Fields must be tested in multiple locations prior to every game and must be below 100 Gmax at all locations. If hardness levels begin to approach 100, steps must be taken to lower the Gmax value.

Clegg Impact Tester – Photo courtesy of Tom Serensits

The American Society for Testing and Materials (ASTM) standard (F1936) uses the F355 device to test surface hardness on natural and synthetic fields and sets an upper limit of 200 Gmax. According to ASTM Standards, a value greater than 200 Gmax qualifies for the expectation that life threatening head injuries may occur. The Synthetic Turf Council (STC) recommends Gmax does not exceed 164 when using the F355 device.

How often should field hardness be tested?

Field hardness levels should be tested upon installation of the field, then continue once per year or more. ASTM Standards recommend measuring field hardness

at least once per year. While these are the written recommendations, testing once per year is not likely to hold up in a liability court case. To ensure field safety, sports turf managers at all facility levels are advised to test throughout the season.

F355 Device – Photo courtesy of Tom Serensits

Gmax measurements are not static. As a synthetic field ages, Gmax values tend to increase. The amount of the increase and the rate at which it occurs depends on construction of the field, materials used, amount and level of play, practices and drills, environmental conditions, and frequency of field maintenance. On natural grass fields, surface hardness levels can vary throughout the year and throughout the life of the field. Hardness levels are dependent on moisture levels, field use, type of turfgrass and density of coverage, field construction, materials used, amount and level of play, practices and drills, environmental conditions, and frequency of field maintenance.

Testing can be completed in-house, or by independent field testing agencies. Some field owners invest in a Clegg Impact Tester so fields can be monitored on a regular basis. The cost of a Clegg Impact Tester is approximately $4,000. F355 devices are more expensive. If testing must be conducted by an outside agency, contact your turf manufacturer for a list of testing providers in your area. If budget limitations are preventing field surface testing, consider purchasing a Clegg Impact Tester and sharing it with neighboring school districts, parks, and community facilities.

Fields become unsafe over time; therefore, frequent testing demonstrates a serious commitment to athlete safety. Additionally, frequent testing can alert field managers to any problems that may be developing before they become critical, which can in turn extend the life of the field. Frequent testing also generates a historical record that may be important if a warranty or liability issue were to arise.

How can field hardness be alleviated?

Natural Grass

Surface hardness on natural turfgrass fields can be reduced by conducting routine maintenance such as aeration and irrigation. The best way to alleviate soil compaction is through mechanical aeration. Mechanical aeration methods improve turfgrass areas by relieving compaction, managing thatch, and creating channels in the rootzone for air, water, and nutrients to penetrate and reach turfgrass roots. For optimum performance, fields should be aerified a minimum of twice per year with highly compacted areas, such as goal mouths, receiving more frequent aeration. Aeration frequency can vary depending on soil type. For example, native soil fields typically need more frequent aeration than a predominantly sand rootzone.

Core aeration should take place in the offseason, with the most common times following the final game in the fall and once again in the early spring. Core aeration should not be conducted immediately before or during the playing season due to disruption to the playing surface and cores possibly affecting play. There are various other mechanical aeration alternatives that do not disrupt the soil surface and can be completed during the playing season. For example, solid tines work to fracture the soil to temporarily alleviate compaction and allow air, water, and nutrients to reach plant roots. Slicing is another alternative that provides temporary relief from compaction; however, results vary widely depending on soil type. STMA recommends researching the various mechanical aeration methods and contacting local manufacturers to determine what solution is right for your field.

Additional practices that can help alleviate surface hardness include topdressing, irrigation, and maintaining healthy turfgrass cover. Adding compost topdressing or ceramics (inorganic amendments) in combination with aeration practices can reduce surface hardness while also creating better conditions for turfgrass growth. Irrigate as needed to ensure the field has adequate, but not excessive, soil moisture levels. Under dry conditions, the surface will be harder. Having a healthy, dense stand of turfgrass not only provides cushioning to reduce surface hardness, but also better traction to reduce leg injuries.

Synthetic Turf

Sports turf managers can incorporate best management practices to reduce field hardness by maintaining proper infill depth on synthetic turf fields. Infill levels should be measured on a regular basis and compared to the infill depth recommendations provided by the field manufacturer. When infill levels drop below the field manufacturer's range, additional infill should be added. Typically only high use areas, such as goal mouths, will require additional infill. Always have extra crumb rubber on hand and be sure it matches what is currently used on the field. Reconditioning of the infill can also eliminate the sand layer that develops from separation of the infill. Deep grooming or cleaning can also soften the infill. If the field is painted regularly, paint can build up over time and result in increased surface hardness. Monitor Gmax values of painted areas closely. The NFL suggests that paint be removed after approximately every four paintings on synthetic fields.

Conclusion

Research continues to be conducted on the safety and playability of athletic fields. Research results provide owners and administrators with scientific data that will help them determine the most appropriate playing surface for their unique situation. Make certain data is from a reliable entity as there could be biased information from organizations aligned with synthetic turf and from those that support natural turfgrass.

Injuries are an unfortunate part of sports. However, a proactive approach to field safety can help minimize injury risk. Documenting routine surface hardness testing, adding crumb rubber when infill levels drop, proper maintenance of natural grass surfaces, educating parents, users, and administrators are all things that can be done to provide the safest field possible. At the end of the day, the safety of the athletes using the fields is the number one goal.

Resources
Contributions from 2014 STMA Information Outreach Committee

From the Field: Field hardness impacts head injury risk – Tom Serensits - http://usafootball.com/news/field/field-field-hardness-impacts-head-injury-risk

Turf issue: Most area schools not regularly testing safety of sports fields – Andrew McNitt, Ph.D. - http://www.personal.psu.edu/asm4/blogs/pennstateturf/2010/11/most-fields-are-not-tested-for-hardness.html

Understanding Gmax – Penn State's Center for Sports Surface Research - http://plantscience.psu.edu/research/centers/ssrc/documents/understanding-gmax.pdf

Update on field safety testing - http://www.sportsturfonline.com/ME2/Audiences/dirmodasp?sid=&nm=News+and+Features&type=Publishing&mod=Publications%3A%3AArticle&mid=8F3A7027421841978F18BE895F87F791&AudID=374222F1A4794C91A8E3D4464352DF70&tier=4&id=C8F11DECDEE2424FAAEA8352B601F91D