BASIC GUIDE TO INSTALLATION AND PREPARATION OF FOOTBALL FIELDS

MODULE 4

- CONMEBOL -
EVOLUCIÓN

Unit 1

Use of the stadium for major events

The management of stadiums and new arenas is increasingly seeking to create multi-purpose spaces to generate other sources of income to justify the high investments made in these places.

Large tours of international artists have been coming more and more to South America, having agenda in the main cities for large concerts. There have also been car racing events, religious events, etc.

It is the responsibility of the team in charge of the field to understand these demands and prepare to organize these important events, which unfortunately often coincide with the team's tournament season.

The most common way to protect a natural lawn is by using special coatings, which will reduce wear and allow some ventilation through the holes in these materials.

Public grass cover

When the natural grass area is to be used only to accommodate the public, the risks are minor.

Excellent quality materials, developed for low weight loads, are already available and will be installed in areas where people will trample the field. These materials are often supplied in rolls or large slabs that fit together, and can be assembled and disassembled very quickly. They are specific for this purpose and are designed with a system of small holes that keep the turf ventilated.

Providing only one event on the field, one night, generally this cover will be placed the day before the event, allowing for monitoring by inspection agencies the day before, and will be removed at dawn, immediately after the end of the event. Therefore, it will often be installed in less than 48 hours, covering the turf, without causing further damage to the field.

Stage turf cover

When the stage needs to be installed within the four field lines, special care must be taken. The stage is the first structure to be started and the last to be completely removed. The larger the structure, the longer the assembly time.

The entire process should be thoroughly discussed with the company responsible for the event.

It is necessary to evaluate:

- plant loads (weights) at each point of the lawn, to avoid possible soil subsidence;
- floor plan of the total area to be occupied by the stage;
- assembly schedule, detailing each step;
- entrance and exit areas of structures.

With all this information, planning should be done to reduce the risk of permanent damage to the turf. This planning should include:

- Daily protection and change of the location of the stage assembly runners;
- Application of protection products in the field, to be defined with the guidance of an agronomist;
- Management prior to coverage, which should include mowing and changing the irrigation pattern of the field;
- Distribution of weight loads from the stage, using shoes, so that the weight is not concentrated in specific locations;
- Monitor the entire assembly, if necessary to keep employees on shifts, covering 24 hours, to avoid damage to field structures. Remember that the turf has buried structures, such as irrigation pipes, sprinklers, drainage system pipes and sensors, which can be affected and destroyed during the process;
- Bars selling alcoholic beverages and chemical toilets, common at these events, should be installed outside the natural grass area;
- Provide a thorough cleaning of the grass cover, prior to removal. This cleaning will remove food debris and other debris left ~~on the roof~~ by the public;
- If possible, allow the grass to be covered at the end of the day, when there is no longer direct sunlight on the field.

The mounting schedule should be as dry and fast as possible, as this greatly reduces damage to the turf.

You should negotiate with the company that performs the event to provide 24-hour service, to optimize the result. In fields already subject to the shadow of the roof structure, the damage may be greater.

The time of year in which the event will be held also greatly influences the damage that will be observed on the natural grass.

Fields with winter turf (cool season turf) that are covered in very hot weather, even for a few days, may have yellowing and dieback of some areas of turf.

Events held in weeks of high humidity will also further damage the turf, which will be more prone to disease.

Post-event management

The field should be discovered as quickly as possible, especially in stadiums that are in tournament season.

Before mowing the lawn, after removing the cover, a magnetic brush should be applied over the entire field, removing any metal parts that have been hidden inside the lawn profile. This service is indispensable to be done in the place where the stage is installed. These metal parts can destroy the mowing equipment and harm the players.

Have a team in place to carry out field reclamation management, which may include brushing, fine cleaning, cutting, application of reclamation products and dyes, in case the schedule of events foresees immediate field games.

A thorough review of the turf by the agronomist is necessary to identify possible sinkholes in the soil that may have occurred and to test all systems, mainly the activation of irrigation.

Depending on the number of days that the field will be covered and the recovery period until the next game, it is necessary to change the grass, partially or totally. If this possibility is chosen and the costs can be covered by the event, it will be necessary to prepare the crop in the best possible conditions, already in perfect playing conditions, with fertilization, leveling, mowing, mattress control, already seeded with winter grass if that is the case. This management was previously discussed in Topic 2 of Unit 1 of Module 2, on the reforms at the end of the seasons.

Unit 2

Technologies for court construction

Vacuum drainage and ventilation

The vacuum and ventilation structure, when installed in a covered and shaded stadium in regions with heavy rainfall during tournaments, is an excellent tool that will greatly assist in turf management and turf health conditions. In this situation, soil moisture and lack of ventilation can cause major problems such as algae, fungal diseases and loss of turf density.

The system is installed in association with a drainage infrastructure in a drainage mattress method, with gravel mattress and sand top layer.

This system was designed to manage soil moisture content and remove excess water from the soil profile. It will work by creating a vacuum, and can also operate in reverse mode, with pressure insufflation.

In ventilation, insufflation takes place throughout the entire gravel profile, which facilitates gas exchange in the root area. This brings benefits throughout the year.

It consists of a system of larger diameter pipes, installed under the soil, along with a layer of gravel and sand. Underneath these pipes, a plastic blanket is installed over the entire base of the field, which will keep the system separated from the base soil and allow a vacuum to be created in flood situations.

An automatic air check valve is also incorporated into a water separator to provide a means of shutting off the piped drainage network from gravity drains. This system allows air to flow up or down in pressure or vacuum mode through the soil profile.

The pressure fan, associated mechanical equipment and system control panel are installed in a room in the stadium near the field, usually under the stands. This machine is tailor-made for each particular stadium. This equipment is connected through a subway air pipe to the water separator and to the network of pipes placed below the surface of the turf.

The system is managed through a panel, located in the engine room, which allows manual operation, predefined daily scheduled operation and others that can be integrated with it.

This system is based on the following components:

- Waterproof sealed playfield barrier system.
- Properly designed main and secondary drainage connection system.

- Connection of the drainage system to an air and water separator tank, properly sealed and incorporating suction pumps and a gravity outlet to the outside of the stadium.
- Purpose-built controlled and managed ventilation/exhaust system with adequate air suction capacity.

Practical experience with vacuum and ventilation systems shows that in stadiums with a lot of shade and little ventilation it really helps to have this tool, which can be activated at different times, even helping in disease control.

In games that may occur during heavy rains, the vacuum will help a lot and will result in a few minutes after being activated, actually drying the field profile, allowing play to continue.

Supplementary lights

With the aim of providing comfort to fans, reducing the discomfort of watching games in rainy or even sunny conditions, a process to cover the stadiums began.

In Europe, this trend is already established and fully justified due to the very low temperatures in winter. But, in general, these fields have completely enclosed roofs, or sometimes with a retractable roof. And most of the time, they will have synthetic turfs, or temporary turfs, which are installed for some big event and then removed, returning to synthetic flooring.

In Brazil, during the preparations for the 2014 World Cup, 14 large stadiums were built from scratch or largely renovated all of them with some kind of covering, and all, at that time, to be used with natural grass. Considering the conditions of a country with a tropical and subtropical climate, Bermuda grass hybrids (*Cynodon*) were used in these stadiums, with the exception of the *Corinthians* stadium in São Paulo, where it was decided to use *ryegrass* (*Lolium perenne*) with a soil cooling system to keep you alive during the summer.

Great challenge to keep the Bermuda zeped alive in very aggressive shading conditions, as there are roofs that were designed extremely closed and very high stadiums.

In general, *Cynodon* is up to three times more demanding in terms of insolation than grasses in cold climates, which require less light.

Today these lights are already present in other stadiums in South America, which are adopting the use of lighting supplements to improve the performance of the fields in the winter periods, when the most important tournaments take place.

The use of supplementary lights is a very important tool, which needed to be adopted in the vast majority of stadiums, and required a thorough understanding/learning from the professionals (agronomists) who operate these fields and who had not yet encountered this problem, as they only had open stadiums, in regions without problems of lack of sunshine.

For the companies that operate these courts, and in some cases the clubs themselves, this system entails very high costs, both in the purchase of equipment and in the operation of the same during the winter months, which requires high energy costs.

To help make a decision on the amount of equipment to be purchased, the time of operation during the whole month and during the whole year, it is recommended to make a shadow analysis, preferably by an independent laboratory, which is not the same that will sell the equipment.

This analysis will take into account:

- geographical coordinates of the stadium;
- project floor plan, with ceiling heights and coverage;
- roof closure angles, roof design, in relation to the size of the lawn;
- variety of turf to be used, which will directly affect the number of units to be purchased.

Therefore, it is possible to define the number of equipment to be purchased and their operation during the months of the year.

In general, the study should indicate for each month of the year, the ideal positioning of the light units and the number of hours.

Below is an example of two studies for the use of equipment with 360 m² of lighting coverage (18 positions to cover the entire lawn), in terms of days of lighting per month, needed for each position, to achieve 35 mol/day (need for a warm climate lawn - Bermuda):

Figure 1: study of light unit positions (360 m2) throughout the year, Stadium X, considering warm weather turf

Approach positions

P01	P04	P07	P10	P13	P16	North
P02	P05	P08	P11	P14	P17	
P03	P06	P09	P12	P15	P18	

Goal (mol/day)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00

January

11	11	11	11	11	11
7	7	6	6	7	8
11	11	11	11	11	11

February

13	13	12	12	13	13
10	9	9	9	9	10
13	13	13	13	13	13

March

16	16	15	15	16	17
13	12	12	12	12	14
16	16	16	16	16	17

April

20	19	19	19	19	25
17	16	16	16	16	23
20	19	19	19	20	25

May

24	24	24	24	28	29
22	22	21	21	26	26
24	24	24	24	28	26

June

25	25	24	25	29	26
23	22	22	23	26	24
25	25	25	26	28	24

July

24	24	24	25	29	26
22	22	22	22	26	23
24	24	24	25	28	24

August

20	20	20	20	25	26
18	17	17	17	23	23
21	20	20	20	25	23

September

17	17	17	17	17	23
14	14	14	14	14	21
17	17	17	17	17	23

October

14	13	13	13	13	14
10	9	9	9	9	11
14	13	13	13	13	14

November

10	9	9	9	10	10
6	6	5	5	6	6
10	10	10	10	10	10

December

10	10	10	10	10	11
7	6	6	6	6	7
11	10	10	10	10	11

Source: CONMEBOL, own elaboration.

Figure 2 study of light unit positions (360 m2) throughout the year, Stadium Y, considering warm weather turf

Approach positions

P01	P04	P07	P10	P13	P16	North
P02	P05	P08	P11	P14	P17	
P03	P06	P09	P12	P15	P18	

Target (mol/day)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00	35,00

January

0	0	0	0	0	1
0	0	0	0	0	0
0	0	0	0	0	0

February

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

March

4	2	1	1	3	8
0	0	0	0	0	0
0	0	0	0	0	3

April

15	14	14	14	16	21
11	10	10	10	11	14
12	11	11	11	12	15

May

22	21	21	23	25	29
18	18	18	18	19	24
18	18	18	18	20	22

June

26	25	26	27	29	31
23	22	22	23	24	28
23	22	22	23	24	27

july

25	25	25	27	29	32
22	21	21	22	24	28
22	21	21	22	23	27

Augu st

21	20	20	21	23	27
17	16	16	17	18	22
18	17	17	17	18	21

September

12	11	11	11	13	18
8	7	7	7	8	11
9	8	8	8	9	12

October

2	0	0	0	1	6
0	0	0	0	0	0
0	0	0	0	0	1

November

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

December

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Source: CONMEBOL, own elaboration.

In the above examples (stadiums located in the southern hemisphere), some factors can be observed such as:

- The variation in the need for use throughout the months, increasing as the winter months (June, July and August) approach.
- The highest demand for light in the northern positions.
- The difference between the need for lighting between stadiums, which will be related to their orientation, geographical position and roof design.

There are different types of equipment, with different coverage of the total lawn area.

From small equipment, with 50 square meters of affected area, dimensioned to be used in the goal and penalty areas, or in small places, such as an exit of the technical area, in front of the players' bench, etc. These smaller pieces of equipment are easy to transport by two people effortlessly, changing position.
Larger teams vary in size and coverage area, from 140 m² to 1200 m², but in general they are sized to occupy 1/18 of the field in the area, approximately 360 m².

In addition to the widely used light bulbs, much effort has been invested in the quest to reduce sports lighting system costs. Light emitting diodes (LEDs) are an attractive alternative light source as they have a much longer operating life (tens of thousands of hours) and equivalent or greater efficiency than HIDs (high intensity discharge lamps), which include fluorescent, sodium "HPS", metal halide "MH", mercury vapor "HgV" and low pressure sodium "LPS". The success of an LED lighting system for turf growth depends largely on the choice of colors. It is possible to choose colors from the light spectrum used by the plant for specific purposes. The composition of different wavelengths of the LED has effects on the hormonal balance and development of plants, to optimize the growth of the lawn, recovery and resistance of plants in the field. In addition, they have long service life, superior brightness and efficient heat dissipation. LED has many advantages, such as flexibility in light spectrum and energy efficiency, but also some challenges, such as high investment costs, lack of infrared radiation (responsible for the additional heat needed to stimulate growth during severe winters) and weight.

Equipment operation:

Most of the equipment used is large, 13 meters long and 20 meters wide when open, and 2.3 meters wide when closed.
Transporting this equipment to the field can be done with the help of utility equipment, with appropriate tires, or preferably pushing by hand, when four people are needed to drive them safely, as there are no slopes from the storage site to the field.

For the use of lighting equipment, additional manpower is required, especially when transportation to the field is done manually, but even when motorized, additional overtime must be provided to optimize the time of the connected equipment, on weekends or vacations and in anticipation of its return outside working hours, just after the end of training and games. Most models of lighting equipment keep their wheels in the turf and these should be moved daily, at least half a meter, so as not to cause permanent damage by compression, on the turf. However, the lighting can remain on for a few days in the same place, just by providing this minimal displacement of the wheel set.

Tires should be kept well calibrated to minimize damage to the soil surface as the equipment moves. Even so, there may be formation of depressions in the field in the maneuvering areas of the wheel sets, mainly in conditions of high soil moisture or at times when the soil presents low compaction, such as after aeration processes.

Large equipment generally have heights greater than 2.5 m, but with a clearance from the surface of the field to the lowest part of the equipment, 1.70 m in height. Even so, it is possible to perform a good part of the handling, such as mowing (depending on the height of the cutting equipment used) and fertilizing, without having to remove the equipment from the field, but only by moving them so that their wheels do not obstruct the operations. However, for safety, avoiding possible burn effects on the turf, which will depend on the type of product used, the lights should be kept off for a few hours after the application of granulated or liquid fertilizers or after pesticide treatments.

Experience in the use of this equipment, throughout the seasons, will provide confidence to the agronomist in charge as to what steps they can take and keep the equipment connected.

When used properly, at the recommended number of hours, it is common to observe increased turf development over areas of artificial lighting, as the entire stadium will be in a partially shaded condition, and these spots with supplemental light will be strengthened. Sometimes it is necessary to consider applying larger doses of fertilizer to lighted areas.

The greater the number of lighting units required to keep the turf in proper condition, the greater the need to plan and work to reconcile field lighting with field management operations or game use.

These moving operations with equipment removal and re-entry require labor time. In addition, the number of hours the lights remain off for this process will interfere with the effective use of the field lighting and, as a result, the maximum possible use of the equipment should be provided in hours of turf lighting, providing replacement after outings and use on weekends and holidays. Be very careful with frequent transit of equipment on the lawn. In general, the less the equipment is moved, the less damage to the field. Turfgrasses that have a fiber reinforcement system installed in the soil profile will generally have less damage.

Another important point is to provide for the storage of this equipment when it is not in use, either for a longer period of time, usually in the summer months, when in most cases the need for artificial lighting can be reduced to zero, or for short periods during games, for example. Both the location for the safe storage of this equipment and its movement, with areas that allow for maneuverability, should be planned in advance.

Shading effects:

Having a shaded situation means that not enough light is supplied to the turf for efficient photosynthesis to occur. Reduced photosynthesis results in reduced carbohydrate synthesis and, in turn, causes stressful conditions in the turf, resulting in insufficient growth and development.

Morphological changes that occur as a result of shade stress include decreased leaf thickness, decreased plant density, decreased tillering (rhizome and/or stolon growth), decreased budding. Roots are greatly affected by reduced light resulting in a decrease in root/shoot

ratio. Reduced stem density and increased leaf height and elongation (etiolation). Physiological responses of turfgrass to shade include reduced carbohydrate reserves, reduced sweating, reduced respiration, reduced cuticle thickness, and increased succulence. In turn, these morphological and physiological changes, as a result of shade, increase the susceptibility of athletic fields to increased wear and tear while reducing their ability to recover from traffic damage.
Bermuda grass, which forms the base of many fields, generally does not promote rooting in these shaded conditions. Within the*Cynodon* genus, there are varieties with greater or lesser shade tolerance, and these characteristics should be evaluated when deciding on variety choice. Environmental conditions that typically accompany shade stress situations include increased relative humidity, more moderate temperatures, and restricted air movement. In turn, athletic fields become more susceptible to diseases common to low-light turfgrass.

Fiber floor reinforcement

Hybrid turf or reinforced natural grass is a product created by combining 100% natural sports turf with synthetic reinforcement fibers. It is used for stadium fields, where there is no sun or temperatures necessary for vigorous rooting. The synthetic fibers incorporated in the root area make the turf stronger and more resistant to damage, helping to reduce the wear and tear of natural grasses and creating a stable playing surface, with the roots intertwined with the fibers below the surface.

Hybrid soil reinforcement (stitched fibers):

It involves the injection/sewing of 200 mm strands formed from plastic fiber into the existing turf surface to increase soil stability. This technique can also be done prior to seeding if a cold climate grass species is used, with seeding by seed.

The system consists of injecting (stitching) millions of fibers into the surface, approximately 20 mm above the soil surface. The fibers are generally injected at a depth of 12 to 15 cm below the surface. The system requires equipment to stitch the fibers together. The surface must be stable to facilitate movement of the equipment. In recent years, the change in recommendations regarding the selection of sand types and maintenance techniques has increased the efficiency of this system. It has been an option for fields that will receive a very high usage load because, no matter how much the plant layer is lost, this system maintains soil stability. On the downside, this system will make it difficult to maintain in the field over time.
Aerations can only be done with solid tines, as hollow tines will pull the fibers. It will also be difficult to manage the exchange of sod loaves in the most worn areas, or less exchange or maintenance of irrigation sprinklers. In these cases, removing the soil ends up losing the entire layer of fibers, which will need to be sewn back together again, manually.

Elastic fiber floor reinforcement:

It consists of a mixture of polypropylene and polyethylene fibers to create a reinforced matrix in the upper sand layer, to a depth of 150 mm.

This mixture is made during the construction phase of the field. The fibers are intertwined to create a reinforcement with the sand, in which the natural grass must grow. These products have been improved in recent years to allow the addition of elastic fibers, reduce surface hardness, increase soil stability and maintain ground cover.
The mixing of materials is done using specific equipment, which involves feeding and mixing their components (fiber, elastic, sand). The product of this mixture is called elastic fiber, with a predefined consistency. It continues with its application to the 15 cm surface of the floor and with the grading of these materials within the floor, using specific equipment. Leveling the surface gives the final finish before planting the turf.
These fibers also greatly aid in soil stability and, unlike the material discussed above, allow for plate exchange and other field maintenance, and even aeration with hollow spikes can be performed.

Unit 3

Performance measures

Performance tests are used to evaluate the playability of a field, associated with the safety of the players, avoiding authorizing the use of fields that do not present reasonable conditions of use. They can also measure and evaluate the variability between very different fields, during tournaments, or verify the conditions of a field, verifying points of non-compliance in specific areas of the turf. Among the purposes for performance testing, we have:

- Develop standards to compare a field to an official sporting body standard, for example, or to compare different fields to each other.
- Determine an overall quality score or rating before using it in a field.
- Obtain information for decision making.
- Examine the risk of harm to the player.

The following measures are some of the main tests used as a parameter to evaluate turf performance:

- Soil moisture
- Soil compaction
- Surface hardness
- Turf traction
- Grass height
- Ball Bearing
- Ball bounce
- Soil temperature
- Root mass/depth - *Thatch*

Types of equipment used for performance testing:

- Moisture: is evaluated by sensors that generally measure soil moisture at a depth of 1.5 to 8 inches (3.8 to 20 cm), expressed as a percentage of volumetric water content (%).

Figure 3

Source figure 3: CONMEBOL, 2020, own archive, unpublished.

Adequate moisture is essential for the development of grass without water stress, but it is necessary to maintain a firm surface, without suffering deformations due to excess moisture during trampling.

The maintenance of an ideal humidity goes through the proper irrigation management, but it starts with the field drainage project, with the correct choice of the materials that will compose the soil profile. In this way, we can have a lot of variability between fields in this regard.
It is clear that this will be subject to climatic variations, but the challenge is precisely to obtain a field, capable of providing a good quality playing surface, even in adverse weather conditions, with efficient drainage.

Its measurement gives us an idea not only of the overall moisture of the field itself, but can indicate variations within a field that may be associated with problems of unevenness in the irrigation system, such as malfunctioning sprinklers or even places subject to greater shade, so that irrigation should be reduced or focused to achieve the same moisture percentages throughout the turf.

It is an evaluation that can be carried out by the person in charge of the field, on a daily basis, to assist in making management decisions.

Soil compaction: measured by a penetrometer, which determines soil compaction at depths up to 18 inches (45 cm), expressed in pounds per square inch * (PSI). * pounds per square foot.

Figure 4

Source figure 4: CONMEBOL, 2020, own archive, unpublished.

This test indicates important parameters for both turf development and surface conditions.

The ability of turfgrass roots to develop is associated with the degree of soil compaction, being limited when excessive and will directly impact the development of the grass-covered surface. The degree of compaction is related to the pore space of the soil, which interferes with the gas exchange and drainage capacity of a soil. While excessive surface compaction can increase the risk of injury to players, minimal compaction is desired to provide the firmness necessary for play.

Compaction will be associated with the type of base material, and will be greater the higher the clay content in the soil composition, but will also vary with the degree of soil moisture.

This parameter can provide management indications, such as the need for aeration or decompression or even for daily irrigation decisions (a dry clay soil will have a much higher degree of compaction than when wet). The penetrometer allows you to test compaction at different depths, being a tool to manage decisions such as the depth of pins to be used in decompression.

Surface hardness: evaluated by the *Clegg* impact test, which measures surface hardness to a depth of 2 inches (5 cm) of the soil profile, expressed in gravity (*G-max*). It provides a means of measuring and monitoring soil strength. It is used to confirm uniform compaction over large areas of soil.

Figure 5

Source: CONMEBOL, 2020, own file, unpublished.

This test is also an indicator of the compaction of the terrain, as it is closely associated with the playing surface conditions, where the field must be firm enough to ensure optimal playability, without being too firm to the point of increasing the risk of injury to players due to excessive impact.

Turf traction: equipment that measures the rotational traction force of the turf, which influences the ability of the athlete's cleats to cling to the surface until the turf breaks, expressed in Newton meter (Nm).

Figure 6

Source Figure 6: CONMEBOL, 2020, own file, unpublished.

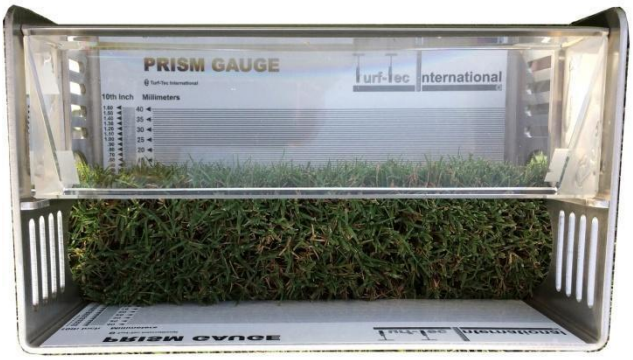
Traction is a very important measurement, as it is associated with playability and athlete safety. A pitch must be strong enough to "hold" the boot locks during play, but break when the player's traction force is high, releasing the athlete's leg.

Therefore, when we have too low traction, there is a risk of the boot slipping during play, but when the traction is too high, the turf could squeeze the cleats of the boots too tightly, causing the athlete's leg to twist, with the risk of tearing a ligament, for example.

Proper traction is the result of a complete turfgrass management condition over time. A turfgrass to have good traction must have received the factors necessary for healthy turfgrass development, such as sufficient nutrients, water and lighting. In addition, it will be a consequence of all other management actions (frequent mowing, verticutting, de-compaction, etc.) taken correctly.
Often, this equipment should be used when making the decision to release a new field for use. Due to the appearance, the field is often green and perfectly finished, but when performing traction tests, it is possible to discover loose spots in the turf plates, which would not be noticeable without this tool.

It should also be used during management activities, when the aggressiveness of an aeration with hollow pins, for example, is defined, which can greatly decrease soil traction, making the use of the turf unfeasible after this operation.
Turf height: The *Prism Gauge* is generally used to measure the height of cut of the turf accurately, allowing visualization of the quality of the cut surface.

Figure 7



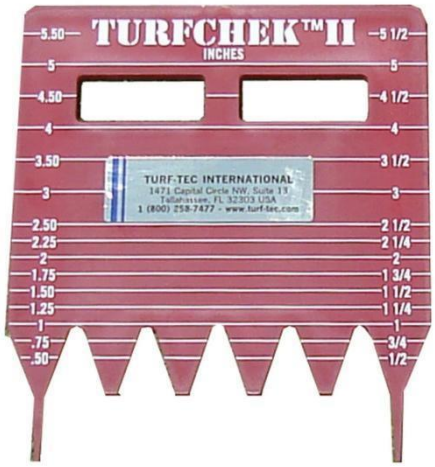
Source: CONMEBOL, 2020, own file, unpublished.

The cutting height should be kept within an ideal range for proper playability. The use of the prism allows not only an accurate reading of this height, but also allows to observe the uniformity of the cut and its precision, as it better exposes the tip of the blades, showing a fraying/scraping due to the lack of sharpness of the blades. It is a heavy equipment, which sits well on the grass mattress, allowing a precise measurement, in millimeters.

As much as field mowing equipment is regulated in terms of its height using precise tools, such as a clamp (pachymeter), different weights of equipment can generally have different cutting heights, hence the importance of making measurements with a prism, reaching the actual height measurement on the turf.

Although without the same accuracy, other equipment, such as the ruler below, can be used to measure height with good results.

Figure 8



Source: CONMEBOL, 2020, own file, unpublished.

Vertical ball bounce (*Ball Rebound*): a football ball is thrown from a height of 2 m, then the height of the bouncing ball after impacting the surface is measured. This is the height of the rebound (bounce) of the ball.

Figure 9

Source: CONMEBOL, 2020, own archive, unpublished.

-Ball roll test: a ball is rolled on a ramp and allowed to roll across the turf surface until it comes to rest. The distance the ball has traveled across the surface is recorded.

Figure 10

Source: CONMEBOL, 2020, own archive, unpublished.

Both the ball bounce and the roll test allow to evaluate some practical conditions of play in the surface conditions on which it will be performed.

They are associated with the density and uniformity of the turf, the regularity of the surface, the presence of *thatch*, among others, and can present management indications such as the quality and frequency of mowing, the need for vertical mowing.

- Soil temperature: use of thermometers with a pine/needle that penetrates the soil, which can be measured in degrees *Celsius* or *Farenheit*.

Figure 11

Source: CONMEBOL, 2020, own file, unpublished.

This parameter helps to make management decisions, such as when planting winter seeds, or helps to identify the ideal germination temperature for certain invaders, for herbicide input. It is also indicative for activating air injection or surface cooling systems.

In addition, it provides an indication of the surface temperature during start-up, which can be a limiting factor when dealing with synthetic turf on days with very high ambient

temperatures.

- Root depth and density: can be obtained by direct observation of a soil sample.

Figure 12

Source figures 3 and 4: CONMEBOL, 2020, own archive, unpublished.

It is indicative of the carrying capacity and development of the turf and is associated with the influence of soil compaction by factors such as nutrient levels, water and light supplied to the turf.

Thickness of*thatch*: Identification of a *thatch* layer (mattress) in turf is easily accomplished by removing a patch of grass with a shovel and examining the cross section from the base to the soil surface.

Mattress (*thatch*) is a layer of decomposed and partially decomposed organic matter placed between the soil and the green vegetation of the lawn. This has beneficial qualities until it becomes excessive (thickness should not exceed one-half inch). When it becomes excessive, it is an indication that the turf is out of balance, i.e., the rate of organic matter accumulation is greater than the rate of degradation. This is usually due to factors that cause excessive grass growth, such as high annual nitrogen rates or high irrigation, in addition to high temperatures. It also has a direct relationship with the type of grass used in the field.

For the game, the lack of thatch (cushion) makes the field very hard, with low impact absorption capacity for the player. On the other hand, when excessive, it interferes with the quality and speed of the ball launch, making the game very slow.
Its evaluation, besides being indicative of the playability of a field, will help to define management practices, such as the need for vertical cuts, groomers, re-evaluation of fertilization levels and mowing frequency.
In addition to these main evaluations exemplified above, there are other equipment and tests that can be used, such as:

- Soil electrical conductivity meter, soil salinity, soil texture, NDVI: Measurement of turf vigor and health, among many others.

As we have seen, performance tests are important to evaluate the playability of a course, associated with player safety. It is important to perform them with the appropriate equipment since the results will be used to make decisions in the management of a course.