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Use of geocomposite drain in soccer field in Brazil

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ABSTRACT: Soccer fields are the toughest of all turf areas to manage due to the inherent problems of utilization and maintenance. The construction and management must provide adequate turf stability and durability while minimizing the chance of injury to players. The most important factor in maintaining the optimal quality of soccer field turf is the drainage. This factor must take into account the turf quality, the playability, and player safety. Based upon this purpose, two design criterion: surface drainage and subsurface drainage are used. Here both are equally important to the good performance behavior of the complete drainage system, each one with its own specific characteristics and drainage capacities. As drainage depends upon rain quantity of a region where the turf area will be constructed, the hydrologic studies are important before the start of any kind of measurement. Today, the incorporation and use of geocomposite drainage systems in drainage work is a reality and the soccer field drainage couldn't be different. Through the same methodology used in the traditional drainage system work, it is possible to offer a complete drainage system for implementation in the design of soccer fields with the use of geocomposite drainage products thereby optimizing the distance between drainage trenches and mattresses.

1 INTRODUCTION

The total turf playing field area depends on good drainage for its correct maintenance and quality. Since during the season or during a game there can not be interruptions due to the accumulation of water in the turf playing areas by unpredictable rainy periods and the resultant formation of water puddles. It is imperative that the drainage system keep the turf area sufficiently dry so that the game development will occur.

The problem is that, even with an effective system of drainage, as the soccer field surface suffers player trampling, the particles of the surface soil (topsoil) will be broken, filling the void spaces of this soil (compaction) and will thereby reduce more and more its permeability. Since the operation of the drainage system depends upon the amount of water from rainfall which passes through the topsoil, if it is "impermeable" the drainage system will be disabled. Therefore, in addition to choosing the correct type of topsoil, its maintenance also should be regularly accomplished. This specific maintenance objective is to reverse the consolidation of the surface layers of soil by employing specialized equipment that allows for aeration, thusly increasing the void spaces in the soil and consequently restoring its permeability. It concludes that for optimal operation of the drainage system of a soccer field it is fundamental that the correct choice of topsoil be made and its continued preservation. With this in mind, the following elaboration will develop and define the calculations that show correct measurement of a soccer field drainage system and afterward its application and operation in a real case.

2 SOILS PERMEABILITY

The permeability of soil is defined through a denominated, coefficient of permeability, this being the time it takes fluid to cross through a determined material. That coefficient is given by Darcy's Law which correlates it with the hydraulic gradient in porous materials. Darcy defines it through the following equation: $V = k.i$, where "V" is the average velocity to the laminar flow, "k" is the coefficient of permeability of the material, and "i" is the hydraulic gradient. The value of k can be obtained easily in a laboratory environment; however, the resultant values are very well defined for determined intervals of granulometry, and can be inferred from available tables (Table 1) found in the majority of texts dealing with

Table 1. Variation intervals for the coefficient of permeability.

	Permeability Coefficient (cm/s) 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10			
Drainage Conditions	Almost impermeable or inadequate for drainage		Adequate for Drainage	
Soil Type	Homo-geneous Clays	Silt Clay Sand Clay	Silt Sand No Clay	Coarse Sand Gravel

mechanical attributes and properties of soils, but not dispensing, of course, its determination in a laboratory. The correct choice of the topsoil depends mostly on the coefficient of permeability, because as it will be shown in sequence, that value is directly linked to the precipitation pluviometric index.

3 SOCCER FIELD DRAINAGE

The drainage in a soccer field occurs basically in two ways: surface and subsurface drainage. The first is of fundamental importance so that is does not allow for the occurrence of water puddle formation and resultant rain water flows for adequate captivation and dispersal. The second is of greater importance regarding surface drainage because it captivates the whole flow of fluid that crosses the topsoil and accelerates the expulsion process of water from the field in order to minimize the accumulation of water in the area where the precipitation actually occurs. As previously stated, topsoil has a very important performance characteristic in the drainage process. Besides allowing the adequate development of vegetation, it will allow the infiltration of water that accumulates due to pluviometric precipitation. Because of this the soil should have a permeability superior to precipitation intensity (mm/h) of the region where the soccer field will be built. If the coefficient of permeability is inferior, it will permit the subsequent formation of water puddles. Thus, there is a logical sequence for the measurement of the subsurface drainage. First, the pluviometric index of the region should be known, and afterwards propose a topsoil type that absorbs to this water quantity and determine the volume of water flow that will be delivered to the subsurface drainage system.

3.1 *Surface drainage*

Though most coaches and players prefer to have a perfectly flat field, this is only possible with a very expensive soilless field. A 2% slope is preferred on most turf areas, but a 1% slope is acceptable on native soil fields given play considerations. For native soil fields, it is imperative to achieve a 1% slope from the center of the field to both sidelines. This will make a crown from 23 to 45 cm at the center of the field depending on the width (Figure 1). A less desirable alternative is to slope the field from one sideline to the other at a 1 to 2% grade. This will provide a "flat" field and allow surface drainage off the field, but is not as efficient as moving water from a field crowned in the center. Many will consider substituting subsurface drain tile lines for surface drainage. This is not recommended because water can be removed from a field more rapidly by surface drainage and will allow play within some hours after rain.

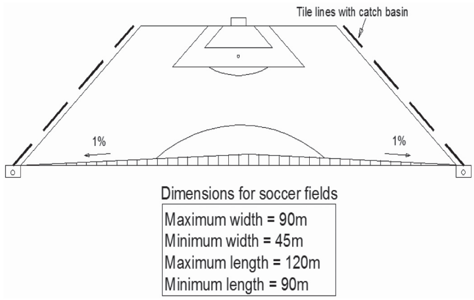

Figure 1. Dimensions and surface drainage plans for soccer fields.

3.2 *Subsurface drainage*

The subsurface drainage system can be built in three basic ways, drainage mattress, drainage trenches, and drainage mattresses plus drainage trenches, making the responsible drainage designer to choose in which situation to use them. It is worthwhile to point out that in some cases a deep drainage system is required desiring the capture of waters already infiltrated into locations adjacent to the affected area (*i.e.* deep waters supplied by previous rainfalls). In this case the measurement of the drainage trenches will proceed in a different way however constructively similar to subsurface drainage systems.

4 THE GEOCOMPOSITE DRAIN

The geocomposite drain can be used as mattress drainage plus trench mattress (Figure 2), allowing

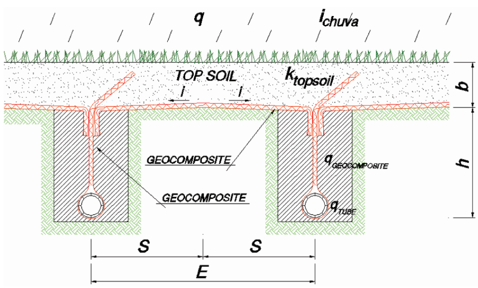

Figure 2. Application detail of the geocomposite.

the capture of the water which will pass through the top soil and afterwards transport it through to the drainage trenches. In some cases it opts for not using the drainage mattress, in these cases the drainage trenches act as collectors and transporters for the flow, however, it becomes necessary that the topsoil presents the ideal drainage characteristics since it will now have the responsibility to send the water flow into the trenches without help for other external agents.

5 TOPSOIL

Topsoil is a sand mixture with organic matter, in a layer with a thickness of 20 cm to 30 cm and importantly will allow for the development of a vegetational root system. The correct sand mixture and organic matter contributes to good drainage through the profile of the soil, since the soil retains some moisture and nutrients for the grass due to the organic matter. There are soil conditioners which can be used as excellent additives of organic matter in the composition of topsoil. The ideal composition for the elaboration of topsoil is between 80 to 90% of average sand and 10 to 20% of organic matter. The source of these materials is very important, because they can contain seeds from damaging herbs, stones and even toxic products that can be counterproductive to the propagation of grass.

Besides the nutrient additives in soil conditioners, it may be necessary to incorporate the use of additional fertilizers and corrective pre-planning for ph levels to improve the fertility of the soil, mostly to improve the development of the root system. Fertilizers with high content of Match are the more preferable for this phase.

6 CASE STUDY

The following actual case study reinforces the necessity for the application of a geocomposite drainage system. This study focuses on the application of a geocomposite drain for subsurface drainage for a soccer field located in Marília City, São Paulo, Brazil, that originally used conventional trench drainage. The drainage characteristics of top soil are important in the calculation of a drainage system, however the main parameter used in the outdoor measurement is the pluviometric precipitation index, and is easily understood the reason why. Topsoil must have a permeability that is coherent with the pluviometric precipitation index of the region. As that index is measured in mm/h, in other words, represents a velocity parameter, and permeability of soils is measured in m/s or cm/s, which also represents a velocity parameter, so that the subdrainage drainage system is in balance and water flows through topsoil without creating puddles is necessary that $k_{topsoil}$ is greater than i_{rain} (Figure 3) existing, theoretically, an immediate infiltration of the rain that will reach topsoil layer.

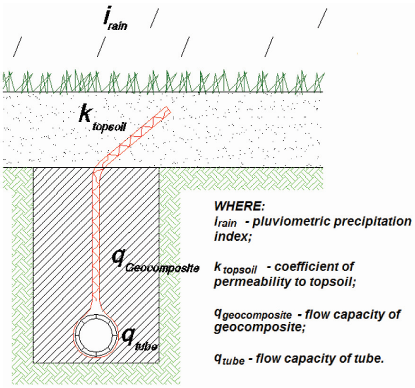

Figure 3. Hidrological and hydraulic parameters used in the project of the drainage trench.

Through the pluviometric precipitation of the state of São Paulo it was possible to derive and average of 10 mm/h as being the highest intensity of rainfall in a period of 48 hours and to use this parameter when initiating the calculations. Making a unit conversion verifies that 10 mm/h is equal to approximately 2.78×10^{-6} m/s, and it concludes that topsoil should present a permeability greater than 2.78×10^{-6} m/s. Thus it was adopted that a permeability rate of 2.80×10^{-6} m/s be used at the parameter of reference for the flow capacity calculation. Having defined the permeability of the topsoil, it is possible to determine the flow capacity that will cross it using Darcy's Law for permanent regimes:

$$q_{topsoil} = k_{topsoil}.i.A \qquad (1)$$

Where, it considers $A = L \times 1$ (L = transversal length to the horizontal flow) as the transversal area that the flow will cross and i as hydraulic gradient equal 1 (vertical drainage). Thence, substituting the values obtains the flow capacity that will cross topsoil layer:

$$q_{topsoil} = 2.80 \times 10^{-6}\ \text{m/s}.1.L(\text{m}).1(\text{m})$$
$$= 0.0028 \times L\ \text{litres/m.s}$$

According to international rules of soccer, the official dimensions of a soccer field are such as shown in Figure 1. Considering a maxims dimensions field, the drainage trenches placed across to the length and the flow direction of the center for the lateral, its width will be able to be taken as half the width maxim, in other words, 45.00 m. Thence, esteeming that each trench will be spaced in 7.00 m, is possible to determine the admissible maxim flow capacity that each perforated tube will support,

q_{adm} = 0.0028 litres/s × 3.50 m × 45.00 m
= 0.441 litres/s

As there will be horizontal contribution in both sides of the trench the flow capacity obtained above, it should be multiplied by 2,

$q_{Madm} = 2 \times q_{adm} = 0.882$ litres/s

In general use tubes perforated of 100 mm in the collection and flow of water, whose flow capacity belongs to approximately q_{tube} = 2.60 litres/s to a slope of 1%, in other words, that tube presents a capacity greater than the necessary to receive the water captivated by the trenches (q_{Madm} = 0.882 litres/s). Considering that to a depth of 1.00 m (depth more than enough for soccer field) geocomposite drain – MacDrain® 2L TD, it will be submitted to pressure of approximately 10 kPa. It has, in its specification sheet for hydraulic gradient equal 1, a flow capacity of 2.84 litres/m.s (Table 2).

Table 2. Flow capacity of geocomposite to i = 1.

Specification Sheet	
Tension [kPa]	Flow Capacity [litres/m.s]
10	2,84
20	2,17
50	1,35
100	0,41

According to international standard, it is necessary to apply the safety factors following:

FR_{IN} = 1.05 (soil intrusion);
FR_{CR} = 1.20 (creep);
FR_{CC} = 1.10 (chemical clogging);
FR_{BC} = 1.15 (biological clogging).

$q_{admTD} = 2.84/(1.05 \times 1.20 \times 1.10 \times 1.15)$

q_{admTD} = 1.78 litres/m.s,

All geocomposite drain safety factors used in this work were determined in laboratory tests.

Geocomposite drain trenches will be used during construction and installation because it is only necessary to dig a trench of 20 cm wide to insert the drain membrane and the reverse placement of the withdrawn soil, which shows its superiority and its application, will be unbeatable when compared to the traditional drainage system. In the following sequence of photos it is possible to view the installation of the geocomposite drainage system by trench method in a soccer field in Marília City in São Paulo, Brazil (Photo 1 and 2).

Photo 1. During the construction of the trenches and insert of the geocomposite drain.

Photo 2. Insert of the geocomposite drain and placement of the withdrawn soil.

7 CONCLUSIONS

In this paper, the calculation methodology used to determine the flow capacity of the drainage trenches with geocomposite drain is the same used in the system of traditional drainage. This can be verified after seeing the real results for a soccer game played on the soccer field where the new drainage system was installed. After raining the soccer field remained sufficiently dry during the game, the ball usually slid and there was no risk to players. A drainage mattress with geocomposite drain was not used in this case, however, its flow capacity is much greater than the absorption capacity of topsoil, the reception of the flow by the drainages trenches alone will be guaranteed.

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