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(54) **SPORTS FIELD CONSTRUCTION**

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(57) **ABSTRACT**

A sports field has a stable, impermeable substrate, a water distributing layer provided over the substrate and an artificial turf layer over the water distributing layer. A bund defines a perimeter of the sports field and extends from the substrate to at least the height of the artificial turf layer. A drain channel having inlets at a height to communicate with the water distributing layer is provided such that water can flow from the water distributing layer into the drain channel and vice versa. As a result of this constructions, there is formed a containment, defined by the bund surrounding the field and by the substrate. Water can be held within the containment in the water distributing layer allowing for water attenuation and cooling of the sports field.

17 Claims, 2 Drawing Sheets

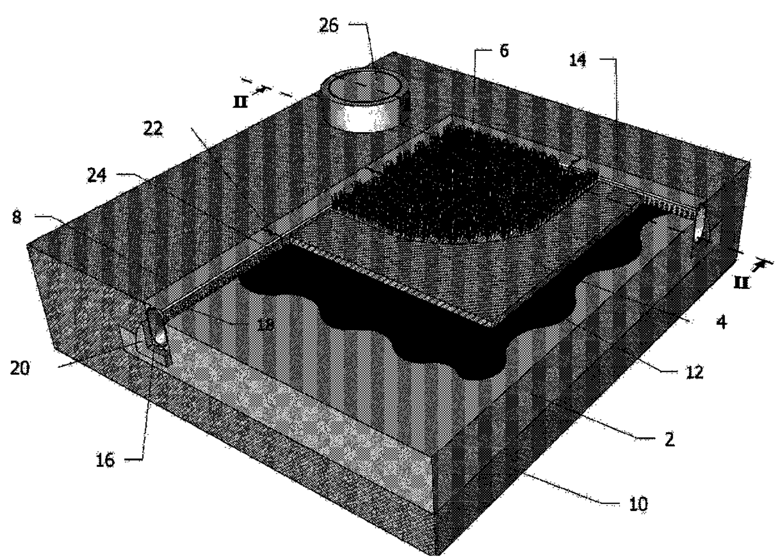

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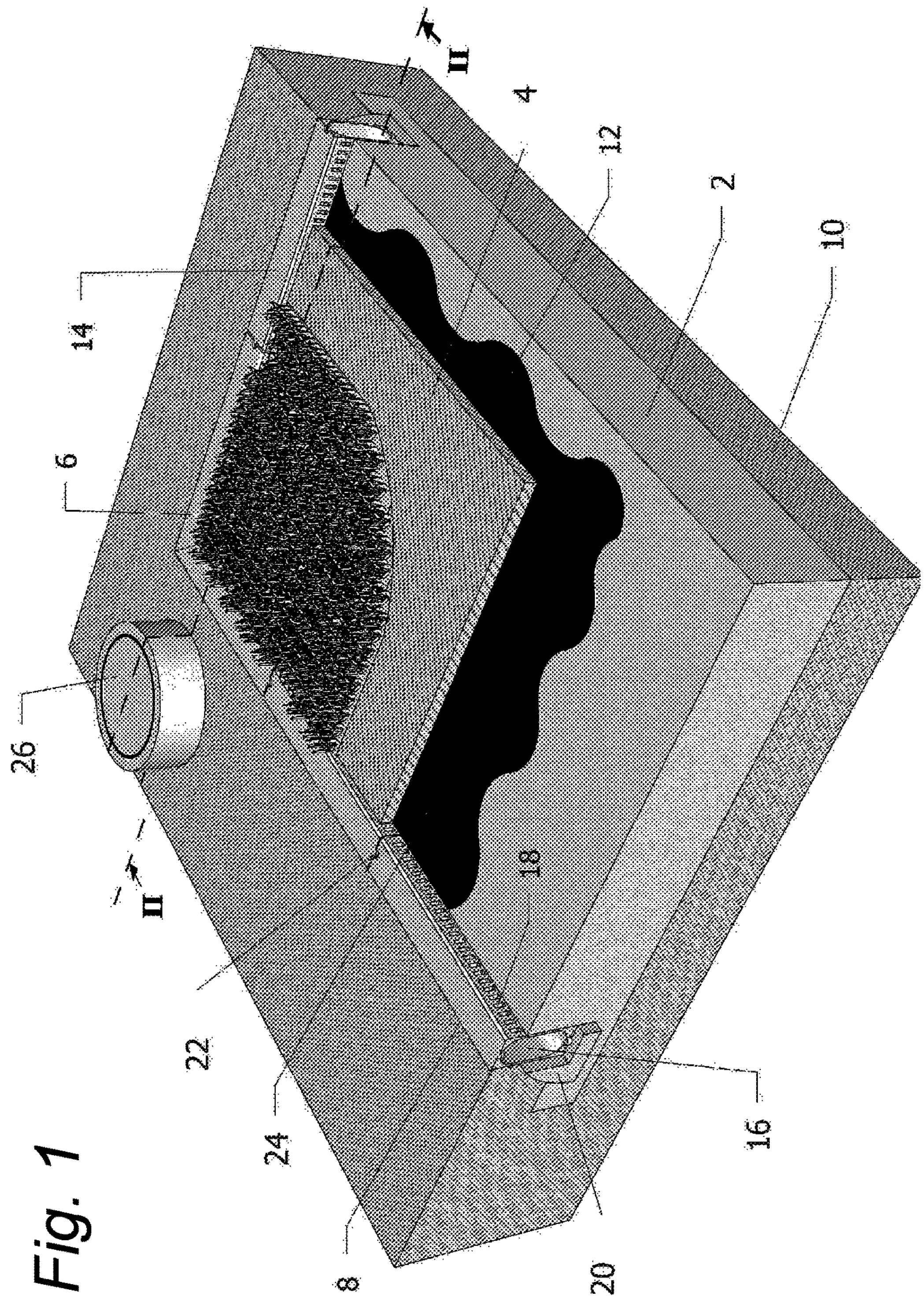
Fig. 1



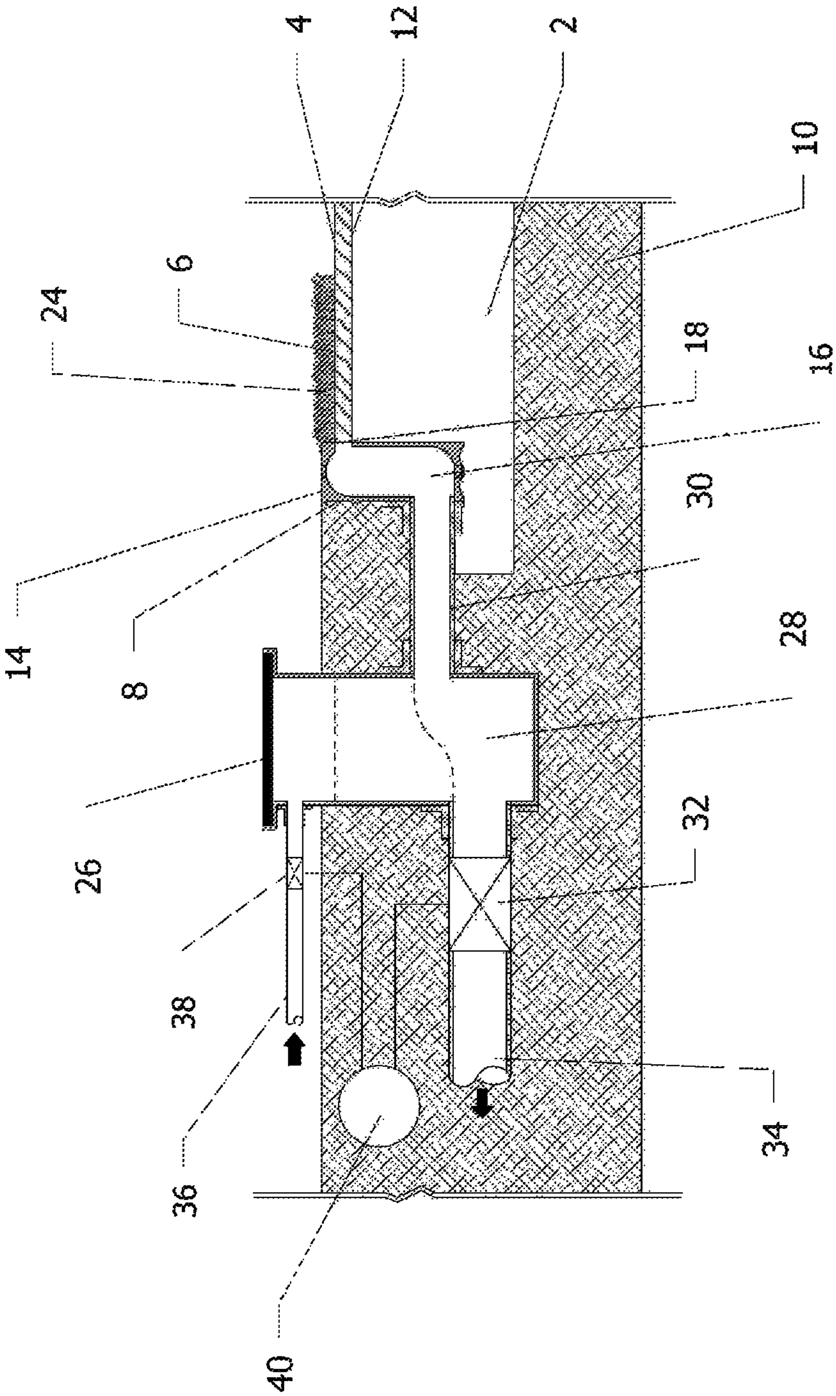


Fig. 2

SPORTS FIELD CONSTRUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to sport fields and in particular, to artificial sports fields comprising artificial turf. The invention further relates to methods of construction for such sports fields and to water management and cooling thereof.

2. Description of the Related Art

Various artificial and semi-artificial sport field systems are known. Semi-artificial pitches usually involve integrating artificial grass blades into a soil base in which regular turf is allowed to grow. The soil base and its drainage arrangements may be otherwise similar to conventional natural grass pitches in order to ensure correct growth of the natural grass.

Fully artificial pitches have developed from first generation Astroturf™ to the present fourth generation systems, which attempt to combine all of the functions and characteristics of natural turf into a single product. In laying an artificial pitch, one fundamental requirement is an adequate base onto which the technical layers can be laid. A significant part of the overall cost of a new installation may lie in the preparation of the base. This should provide a guaranteed level of stability and drainage despite the fact that the underlying earth may vary considerably from one location or region to another.

Another characteristic of artificial sports fields is the difficulty of dealing with elevated temperatures e.g. in the presence of bright sunlight. The surface temperature of the field may rise significantly during the day, changing the characteristics of the technical layers and even giving off unpleasant odours. Play under these conditions may be compromised. Other sports fields may require irrigation before play can commence. In all cases, water management is a central issue that the designer must take into consideration when designing a sports field.

The term "water management" refers to four main areas, these being; drainage, irrigation, storage and attenuation.

- Drainage may be defined as the removal of water from the pitch area to an exit point away from the field construction. Excessive water or surface flooding will adversely affect the play performance and can cause movement of infill materials.
- Irrigation may be defined as the delivery of water onto the turf surface, by a system of pumps, pop-up sprinklers and water cannons. The purpose of adding hwater to the surface may be either as part of the playing characteristics of the surface, or to cool the turf surface. In hot, sunny condition, artificial turf systems may heat up, to the point that the surface becomes uncomfortable and energy depleting to the players.
- Storage may be defined as providing a holding facility which allows water, drained from the pitch, to be used e.g. in the irrigation of the pitch. This may be in an underground reservoir or an above-ground lake. Storage is also linked to water attenuation.
- Attenuation may be defined as the temporary storage of surface water in a suitable reservoir below ground level or in an above-ground lake. This reservoir or lake needs to be of sufficient size to accommodate the calculated run-off during peak periods of rainfall. The stored water may subsequently be gradually released in a controlled manner into a combined drainage system or watercourse, effectively reducing the risk of flooding.

Drainage Systems

Traditional drainage methodology for artificial turf systems has been based around two main methods. The first been the vertical method and the other been the horizontal method.

Vertical Method: There are many variations and systems which come under the heading of vertical drainage, but the basic principal remains the same, that being a matrix or pattern of inter-connecting porous pipes, situated at the bottom of a porous rock base construction. The porous base construction is designed to remove water permeating down from the artificial turf system above, through the upper layers of the porous rock sub-base. These pipes lead the water off the playing area into ring main land drains or similar water drainage control systems.

These pitches may have a profile which assists water movement; this is known as slope or fall. There are various designs of slope and fall of the upper sport surface, such as; Crowned, Enveloped, and Tilted etc. the angles of fall tend to be between 0.4% and 1%. A key issue with porous stone bases is that they are required to have minimum depths of construction due to the limited amount of stone compaction which can be achieved. The target for any base construction is to achieve a certain tested value which ensures the structure has the correct structural integrity and load bearing capacities. As an example, one industry standard method of measuring these values is known as the Californian Bearing Ratio (CBR also defined according to BS 1377-2: 1990), which is expressed as a percentage value. For a sports field, the standard target CBR value after installation is a minimum of 30%. In order to achieve this value for a porous base construction a greater depth must be considered. This is because porous stone constructions contain void spaces in order to allow water to pass through the structure. As a result, the overall strength of the structure is not as high and the stone has more mobility, as compared to an equivalent non-porous base construction.

The presences of water within the porous stone construction also acts to destabilise the formation further and make the formation susceptible to frost heave. In order to address these issues, depending on local geo-logical and climate conditions, porous stone bases typically have a minimum depth of 300 mm.

Another issue is the requirement for expensive, specially graded rock types in order to create a porous base layer. This rock comes from virgin materials transported in by truck. For a standard porous pitch construction of 7500 m^2 and a minimum stone depth of 300 mm it would require 2475 m^3 of stone or 4200 tonnes. Given a standard truck can carry 20 tonnes this will require approx. 200 truckloads. Added to this is the number of trucks required to remove the existing sub-soil for re-location or landfill, being an additional 200 truckloads. This use of virgin materials and the requirement for 400 truck journeys, not only has a high cost but also a large environmental impact.

Horizontal Method: As explained above, the vertical drainage method relies on creating a porous base construction which allows water to percolate down through the various stone grades to the field drains below. The horizontal method uses a limited porosity or non-porous stone sub-base construction with no field drains below. The basic principal is that the water flows across the surface of the artificial turf, through the infill and in some cases, within a shock pad/substrate which allows water to flow horizontally, above the stone sub-base construction. In all such systems and methods, the pitches are designed with a slope or fall, (as explained above) in order to ensure adequate water flow. The water flowing off the sports field surface is then captured by drainage troughs or pipes installed around the perimeter of the turf installation. These pipes, themselves have a slope or fall in order to remove the water to main land drains or similar water drainage control systems.

The benefit of such systems over porous base constructions is the possible reduction of base construction depths, as these formations do not require void spaces and therefore can be compacted. The type of stone can have a wider particle size thereby reducing quarried stone costs. It is also possible to use recycled aggregates in such a base construction format, such as aggregates produced from recycled brick, concrete, asphalt etc. Because these surfaces are non-porous or have limited porosity, water has little effect on the structure of the base layer and therefore frost heave and destabilising effects are limited. In some cases it may be required to install an impermeable liner on top of the stone layer. In order to allow water to drain from the surface the pitch will be required to have a fall or slope. This slope can be constructed in a variety of ways, either in one direction or in multiple directions. The construction of such a slope requires skill from the pitch builder and influences ball behaviour of the finished turf surface. In addition a layer must be installed between the turf and the base construction in order for water to move freely down the slope to the perimeter drains. This layer can be provided by certain types of shock pads and/or geo-technical fabrics.

One horizontal drainage method for a sports pitch is suggested in WO2012138216 which uses a porous sub-grade course laid on an impermeable surface to transport water to the edge of the pitch, where it can be drained away by conventional drains. It is also proposed to use the sub-grade course as a containment e.g. for re-circulation to the playing surface as described below.

Irrigation

Standard irrigation systems rely on water from the mains supply which is pumped to water cannons or pop-up sprinklers located on or around the pitch. In some cases water captured from the pitch's drainage system is piped into storage facilities and recirculated back on to the pitch by means of water cannons or pop-up sprinklers. A filtration facility may also be required in this case. The use of the water is either as part of the turf system performance or for use as cooling during hot weather. For a full-sized hockey pitch from 12000 to 18000 liters may be required to wet the pitch prior to play.

All these methods rely on the same basic principal, whereby water is applied to the top of the turf system and the water gradually drains out of the turf structure. The water cannot be held in place for any medium or long-term time frame, therefore its influence on the turf system in aspects of performance or cooling has a limited short term effect. Because most artificial turf fibres and infill have little or no absorbent properties, water simply runs off through the turf system. The method of applying water by cannons or sprinklers is highly inefficient as much of the water applied is lost as mist before reaching the surface and the accuracy of water placement is difficult to control. The cost of such systems is also high, as well as the financial and environment impact of using water directly from mains supply.

Water Storage

If the requirement or legal obligation on a project is to reuse water captured from the pitch drainage system, or if this water cannot go directly into local drainage systems, then above ground or underground tanks or ponds may be constructed nearby the pitch. As stated above some designs will allow captured water to be irrigated back on to the pitch playing surface. The cost of installing tanks or ponds is high, and areas around the pitch must be set aside for such constructions. In many cases the solution is to dig a large hole and bury the tank. There is furthermore an issue of retained water becoming infected by microbes and algae's. The water can be treated to eliminate such infestations, however care must be taken to monitor and treat the retained water.

At the other extreme, in areas of low rainfall, sustainable water storage or rain water harvesting is a well know practice. These methods include ground and roof capture, sub-surface dykes and ground water recharge.

Attenuation

Sustainable urban drainage systems (SUDS) or low impact drainage systems (LID) are a developing concept that includes long term environmental and social factors in decisions about drainage. It takes account of the quantity and quality of runoff, as well as the amenity value of surface water in the urban environment. Many existing urban drainage systems can cause problems of flooding, pollution or damage to the environment and are not proving to be sustainable.

Built-up areas need to be drained to remove surface water. Traditionally this has been done using underground pipe systems designed for quantity i.e. preventing flooding locally by conveying the water away as quickly as possible. However, the alteration of natural flow patterns can lead to problems elsewhere in the catchment. Furthermore, amenity aspects such as water resources, community facilities, landscaping potential and provision of varied wildlife habitats have largely been ignored.

SUDS systems are designed to act as collection, storage and gradual release of rain water during and after large storm events. There are various types of urban systems in existence; from soak away pits, multiple sub-terrain chambers to open storage lakes etc. all of which are designed to ensure rainwater being collected from non-porous surfaces such as roads, roofs and car parks is directed, stored and then slowly released into the drainage system at a controlled, manageable flow rate.

The major drawback with these systems is the fact they need to be built in urban locations where space is at a premium. Systems which rely on soak away pits or areas of graded rock to hold water and then slowly disperse it by natural ground seepage are also prone to silting up due to sands, clays and fine dirt etc. slowly penetrating the formation.

BRIEF SUMMARY OF THE INVENTION

According to the invention there is provided a sports field comprising: a stable, impermeable substrate; a water distributing layer provided over the substrate; an artificial turf layer over the water distributing layer; a bund defining a perimeter of the sports field and extending from the substrate to at least the height of the artificial turf layer; and a drain channel having inlets at a height to communicate with the water distributing layer such that water can flow from the water distributing layer into the drain channel and vice versa. As a result of this constructions, there is formed a containment, defined by the bund surrounding the field and by the substrate. Water can be held within the containment in the water distributing layer. Because of the location of the inlets and the drain channel with respect to the water distributing layer, water can be allowed to flow out of the containment into the drain channel if the level of water in the drain channel is below that of the water distributing layer.

Alternatively, water can be allowed to flow from the drain channel into the containment if the level of water in the drain channel is higher than that of the water distributing layer. The containment and the drain channel may thus form a common system between which there is no opportunity for water to leak or seep away. In this context, although reference is made to inlets, it will be understood that the water may flow in both directions through them. It is also not excluded that water may flow into the containment through one set of openings and out of the containment to the drain channel through a second set of openings.

In the following, references to a sports field is intended to include any area of artificial turf, including but not limited to pitches, games areas, play areas and the like. Preferably, the invention is applicable to sports areas on which humans play and run although it is not excluded that it may also be applicable to animal sports or motor sports. Furthermore, artificial turf is not intended to be limiting on any particular kind of turf, including turf with artificial infill, sand or without infill.

The bund may be an upstanding edge of the stable impervious substrate. Alternatively, the bund may be a separate kerb installed for the purpose. In one configuration, the bund may comprise a plurality of kerb elements such as concrete kerbing, linked together. The height of the bund should extend above the top of the water distributing layer, whereby at least part of the turf is within the containment. In one embodiment, the bund may extend to the full height of the turf such that the water level may be raised to completely flood the sports field. Although concrete kerbing is readily available and cheap, the fact that it is upstanding to the full height of the turf may create an obstacle, over which players may trip. The bund may also slope upwards from the water distributing layer to the height of the turf and may be surrounded by ground at the higher level. The top of the bund may also be rounded or any other convenient shape. As an alternative material to concrete, the bund may be manufactured from plastics materials such as recycled plastics and may be at least partially resilient to prevent player injuries.

The drain channel may be at any position such that it can communicate via the inlets with the water distributing layer. In a most preferred embodiment, the drain channel surrounds the sports field and is at the same level as the water distributing layer. In a further embodiment, the drain channel may be integrally formed with the bund. In one configuration, the bund may comprise hollow kerb elements that can be assembled together to define the drain channel.

According to one preferred embodiment, the sports field may comprise a water management facility arranged to control the height of the water within the drain channel. In this way, it may be determined whether water flows from the water distributing layer into the drain channel or vice versa. Any appropriate arrangement for controlling the water within the drain channel may be used, including pumps, valves, buffer reservoirs and the like. In one embodiment, an outlet from the drain channel may be connected to the water management facility although again, it is emphasised that the construction may allow flow in both directions through this outlet.

In order to provide adequate control of the water level within the containment, the drain channel may extend both below and above the water distributing layer. In one configuration, the water management facility may have an overflow arrangement to ensure that excess water cannot overflow the bund. This may be important in the case of infill provided in the artificial turf which may otherwise be washed away.

The stable impermeable substrate may be constructed in any appropriate manner to achieve the required stability for the intended sport. In particular, aggregates used can be either from virgin or recycled sources and have a particle size of from 20 mm to dust. The inclusion of cement and or similar agents within the aggregates can be used in order to increase the strength, non-porosity and compaction values.

According to an important aspect of the invention, the stable impermeable substrate may comprise a stabilised in-situ soil substrate. Soil stabilisation techniques are generally well known in various contexts but because of the non-porous nature of the technique, soil stabilisation has not been utilised in the construction of artificial turf pitches. This combination and the ability to use the existing on site soil, represents a major cost and environmental saving on a construction project as material on the job site is not required to be excavated and removed or new graded material shipped to site to build the pitch foundation.

In one embodiment, the soil is stabilised to a depth of at least 100 mm, optionally to a depth of more than 200 mm and in a preferred embodiment to around 300 mm. As discussed above an ideal load bearing capacity of the finished base construction may be CBR 30%. Depending on existing sub-soil types and CBR values some sub-soil modification may be required (i.e. below the base construction). For example subsoils with a value of 4.5% CBR or below may require lime modification, whereas sub-soils of 5% CBR or above need not require such modification. In some construction projects a CBR of 15% may suffice.

The stabilised in-situ soil substrate may be lime-modified. The lime modification process involves the addition of small amounts of binder (quicklime) to the host material to substantially reduce moisture content transforming the wet/unsuitable material into a useable and compactable construction material with a 5% CBR. Additionally or alternatively it may comprise a capping replacement layer or a sub-base replacement layer, whereby binders (quicklime and cement) are incorporated into the host material along with the addition of water. The material may then be compacted and trimmed leaving a layer with the required CBR. Although lime and cement-based stabilisation techniques may be preferred, the skilled person will be well aware of other soil stabilisation techniques that may be applied depending on local soil conditions and locally available stabilisation agents. Such agents may include enzymes, surfactants, natural and synthetic polymers, resins, salts and fibre reinforcement.

In certain embodiments, the stable impermeable substrate may comprise an impervious membrane or coating. The membrane may comprise a geotextile liner. Suitable coatings include bitumen, polymer, resins and cement. This is particularly applicable in cases where the base is not itself impermeable.

According to an embodiment, the water distributing layer has a depth of between 10 mm and 100 mm, optionally around 40 mm. The total depth chosen for the water distributing layer may be dependent on a number of factors. In general, the deeper the water distributing layer, the greater the volume of the containment below the artificial turf and the greater will be the through-flow area for drainage purposes.

If the sports field is constructed without gradient or run-off, the effectively available gradient between the upper side of the water distributing layer in the middle of the pitch and the underside of the water distributing layer at the edge of the pitch will depend on the distance between these two points and the thickness of the water distributing layer. For a football pitch having a distance from centre line to the bund of around 35 m, a depth of around 100 mm may give improved drainage. For smaller fields, a lesser depth may be adequate. It will also be understood that a greater depth may also provide for a greater overall containment but may also lead to greater volumes of material being required for construction.

According to an important advantage of the present invention, the sports field may be formed to be completely level. It will be understood that the bund will generally be completely level, since its upper edge will define the limit to which water may rise without overflowing the bund. Furthermore, the upper surface of the water distributing layer may be substantially horizontal too. In this context, horizontal is intended to denote that it has no appreciable run-off at its surface. It will nevertheless be understood that its absolute level and evenness will be largely dictated by the accuracy and care of placement. In one embodiment the upper surface of the water distributing layer may have no gradient greater than 1 in 100 and optionally less than 1 in 300. It may also exhibit no variation in height of more than 10 mm over a 3 meter straight edge.

The substrate may also be substantially level. In that case, the thickness of the water distributing layer may be constant over the whole sports field. Producing a level substrate is significantly easier than accurately providing a desired slope in one or more directions. It also simplifies the laying of the following water distributing layer to be horizontal and makes possible the construction of the water distributing layer using pre-fabricated elements.

In one preferred embodiment of the invention, the water distributing layer comprises recycled plastic granules and a binder. Such a construction is described in WO2012/138216, the contents of which is included herein by reference in its entirety, and can conveniently be applied using specialist paving equipment used in sport pitch and running track installation. Preferred granule sizes may range from 0.5-20 mm although granules in the range from 3 mm to 8 mm have given good results. It is also not excluded that flakes, rods, pellets and elongated extrudates may also be used. The binder may be any binder appropriate to the granules used and to the intended use and location. Preferred binders include bitumen, polyurethane or polyolefin based binders and they may be present at between 5% and 40% by weight of the granules, preferably between 15% and 25% and in one embodiment at around 20%. The water distributing layer may also be formed according to the method described in EP1603725, whereby partially melted particles of waste plastic material are welded together to form a porous layer. This method may be particularly applicable to preformed layers although it is not excluded that it may also be used in-situ.

The water distributing layer may also comprise other components, in particular other granules. In particular, rubber or stone granules may be included at up to 50% by weight or even up to 70% by weight in the final mixture in order to adjust the technical properties of the layer. Furthermore, the water distributing layer may comprise a number of sub-layers having different properties. This may particularly be the case where the uppermost portion of the water distributing layer serves as a performance layer having required shock absorbing and energy restitution values.

According to the invention, the water distributing layer may be constructed to have a void ratio of between 20% and 70%, optionally around 45%. For an average sized pitch of 7500 m^2 and for a water distributing layer having a void content of 45%, a layer thickness of 40 mm equates to 18 lts per m^2 or 135,000 lts water storage capacity for the entire pitch, excluding the additional capacity of the drain channel. The void ratio may be adjusted by varying the size and shape of granules or particles forming the layer and by varying the pressure applied during manufacture. The water distributing layer may have a specific density of between 300 Kg/m3 and 700 Kg/m3, preferably between 400 Kg/m3 and 600 Kg/m3 and most preferably around 500 Kg/m3.

The water distributing layer may be provided to have engineering properties of strength and modulus according to the intended sport or activity. This will also depend on the nature of the artificial turf layer above and any other performance layers. In certain embodiments, the water distributing layer will be effectively rigid, whereby primary shock absorption for the players is provided by performance layers above the water distributing layer. According to one embodiment of the invention, the water distributing layer may have a Young's modulus in compression of greater than 0.1 MPa, alternatively greater than 1 MPa and in an embodiment, greater than 2 MPa. In general, the Young's modulus in compression will be less than 50 MPa, alternatively less than 10 MPa and in an embodiment, less than 5 MPa. In other embodiments, the sports field may further comprise a resilient layer provided between the water distributing layer and the artificial turf layer.

The invention also relates to a method of constructing a sports field comprising: providing a stable, impermeable substrate; providing a water distributing layer over the substrate; installing an artificial turf layer over the water distributing layer; forming a bund defining a perimeter of the sports field and extending from the substrate to at least the height of the artificial turf layer; and providing a drain channel communicating with the water distributing layer such that water can flow from the water distributing layer into the drain channel and vice-versa.

The substrate may be an existing substrate that meets the requirements of stability and permeability. Such substrates may include brown-field sites, including concrete and asphalted surfaces. Alternatively, the substrate may be formed by any conventional procedure using either materials imported to the site or soil stabilisation of the existing on-site soil as described further above. The stability of the substrate may be at least CBR 15% and if stabilised using soil stabilisation of existing soil may preferably be carried out to a depth of at least 100 mm.

According to a further aspect, the invention may comprise providing an impermeable membrane or coating over the stable base to ensure the required permeability. It will be understood that absolute impermeability of the substrate may be non-critical and merely for the avoidance of water seeping away from the containment. In certain situations, such as rooftop playing fields, absolute impermeability may be a requirement.

As also described above, the method of providing the water distributing layer may in one embodiment comprise in-situ laying of a semi-fluid mass comprising recycled plastic granules and a binder, levelling the semi-fluid mass and allowing the semi-fluid mass to solidify to form a rigid porous layer. The process can be carried out using a conventional paving machine of the type used for road or sports surfaces.

In an alternative embodiment, providing the water distributing layer may comprise paving the substrate with pre-formed porous slabs of recycled plastic granules. The slabs may be made off-site in a controlled process whereby carefully determined performance characteristics may be achieved. The slabs may be provided with interlocking elements and may also be adhered or otherwise affixed to the substrate.

In one embodiment, the method of forming the bund may comprise installation of hollow curb-stones, joined end-to-end to form an integral drain channel. It is also contemplated that a continuous length of drain channel may be installed around the field to form the bund.

The invention also relates to a method of cooling a sports field comprising an artificial turf layer on a porous water distributing layer within an impervious containment, the method comprising filling the containment with water to a depth sufficient to immerse at least part of the artificial turf layer over the full area of the sports field and subsequently draining the water from the containment. The water may be partially drained, to a level whereby the sports field can be used, while retaining water within the containment. Alternatively, the water may be completely drained. By wetting the sports field, the playing characteristics may be improved and additionally both direct and evaporative cooling of the pitch can take place.

In a preferred embodiment, the turf may be wetted from below, whereby the water level in the water distributing layer rises until the turf is either partially or completely immersed. Additional wicking provisions may be included within the water distributing layer or in the turf layer or therebetween to encourage the transport of water to the surface. Irrigation from below in this manner avoids the use of sprays and nozzles, which are often only partially effective and require a higher level of microbial cleanliness than is the case for ground water. The water may be introduced and removed via inlets communicating between the water distributing layer and a drain channel.

The invention further relates to a method of attenuating water in a sports field comprising an artificial turf layer on a porous water distributing layer within an impervious containment, the method comprising collecting rainfall within the containment during periods of rain and controlling discharge from the containment during periods of little or no rain. The water collected may be rain falling on the sports field but may also be water falling on surrounding areas that can be supplied to the containment via a drain channel communicating with the water distributing layer.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the invention will be appreciated upon reference to the following drawings of a number of exemplary embodiments, in which:

FIG. **1** shows a sectional view of a portion of a sports field according to the invention; and

FIG. **2** shows a cross-section through the sports field of FIG. **1** along line II-II showing the water management system.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

Example

FIG. **1** shows a perspective sectioned view of a portion of a sports field **1** according to an example of the present invention. The sports field **1** comprises three main layers, namely a substrate **2**, a water distributing layer **4** and an artificial turf layer **6**. The whole is enclosed by a bund **8**.

The substrate **2** is a soil stabilised layer having a depth of 300 mm as will be described in further below. Underneath the substrate **2** is the natural soil layer **10**, which is also present behind the bund **8**. On the upper surface of the substrate **2** is provided a bitumen coating **12**, which imperviously seals the substrate **2** up to the bund **8**.

The water distributing layer **4** is a 40 mm thick layer of a 50% by weight mixture of recycled plastic granules and rubber granules bound together with a polyurethane binder present at 14% by weight of the total. The resulting layer has a void ratio of around 45%.

The artificial turf **6** is a premier tufted third generation turf having a pile height of 60 mm and a rubber and sand infill available from Tiger Turf™ as Total Turf 60XQ.

The bund **8** is formed by interlocked hollow kerbstones **14** provided with a drain channel **16** and inlets **18**. The kerbstones **14** are of 600 mm depth and the inlets **18** are slots of 50 mm length, extending to a level 100 mm below the top of the bund **8**. The kerbstones **14** are set in a concrete haunch **20** and are sealed to each other by a mastic bead **22**. The substrate **2**, and the bund **8**, together with the drain channel **16** form a containment **24** which is largely impervious and can retain water for a significant period. The drain channel **16** is connected to a water management facility **26**, which controls inflow to and outflow from the containment **24**

FIG. **2** shows a cross-section through the sports field **1** along the line II-II in FIG. **1** showing the substrate **2**, the water distributing layer **4**, the artificial turf layer **6** and the kerbstones **14**. FIG. **2** also illustrates the water management facility **26**, which comprises a chamber **28**, connected to an outlet **30** from the drain channel **16**. It will be understood that although a single outlet **30** is shown, there may be a plurality of such outlets **30** around the periphery of the sports field **1**, connected to the chamber **28** by a ring drain or the like. Chamber **28** is further connected through a valve flow gate **32** to the storm water drainage system **34**. In addition a water supply pipe **36** is attached to the top side of the chamber **28**. In the illustrated example, this water supply pipe **36** is connected to the mains or another source of water such as a recycled water by a stop cock **38**. It will be understood that the water supply pipe **36** may be connected to any suitable source of water such as a recycled water and that a pump arrangement may be provided rather than a stop cock. A controller **40** ensures control of the valve flow gate **32** and the stop cock **38**, which may be automated or manually controlled.

Installation

Installation of the sports field **1** took place by first removing the existing top layer of turf and organic material from the site. The subsoil **10** was then analysed to determine the required soil stabilisation process. In the illustrated example, the soil was a relatively heavy clay soil. In order to dry out and granulate this soil it was mixed with a set dosage of lime to a depth of 300 mm. The process was carried out using a Wirtgen WR2500 SK integrated mixer to ensure that the mixed layer was consistent both in mix quality and also in the depth of the mixed layer. Following this first stage treatment the area was leveled by a laser levelling bulldozer and then rolled with a 20 tonne roller. The area was then left overnight so that the chemical reaction between the lime and the soil could take effect.

In a second stage of soil stabilisation, cement and water were introduced in amounts determined by the analysis in order to create a hydraulically bonded material. The Wirtgen mixer was again used whereby the machine controlled the precise amount of water and cement required. Cement was delivered from tanks inside the machine while water was fed from a browser in front of the machine. Again the soil was treated to a depth of 300 mm. During the process, samples of the mixed material were periodically tested to check that the material was behaving as predicted. Following soil mixing, the laser levelling bulldozer again graded and leveled the materials to a surface tolerance of +−10 mm over a 3 meter straight edge, while the 20 tonnes roller compacted the surface. After completion, in order to seal the finished surface of the substrate **2**, it was sprayed with bitumen coating **12**.

After 3 days the surface of the substrate **2** was CBR measured in 4 locations with the following results:

Location 1—64%

Location 2—30.8%

Location 3—30.1%

Location 4—37%

After 4-7 days of treatment, the substrate **2** was exceptionally stable, would carry heavy equipment and could be trafficked without any effect. CBR levels of around 60% were estimated over the whole surface.

In order to install the kerbstones **14**, a circular saw was used to cut the substrate **2** cleanly with a 75 mm gap to the front of the bund **8**. The kerbstones **14** were then joined to each other with a mastic bead **22** to ensure a watertight seal. Once the kerbstones **14** were installed and set, the water distributing layer **4** was laid. First, the plastic and the rubber granulates were metered in equal amounts using a SMG MixMatic M6008 with additional hopper to add the granules to a 14 wt % PU feed. Then the area was paved using a SMG PlanoMatic P936 to a depth of 40 mm and at a rate of 20 kg of mixed material to 2.8 kg of PU binder per m^2. The final surface tolerance of the paved layer was +−10 mm over a 3 meter straight edge. After 48 hrs of curing the water distributing layer **4** layer was tested using a Deltec™ club tester. The average results from 10 test locations were the following:

Force Reduction—50.2%

Surface Deformation—5.4 mm

Energy Restitution—35.8%

Once the water distributing layer **4** was fully cured, the turf **6** was installed in a conventional manner, and filled with a mixture of rubber granules and sand. The turf **6** was laid up to the bund **8** at all sides and to the same level.

Strain Testing

A sample of water distributing layer **4** manufactured to the same specification as the example described above was laboratory strain tested in compression to determine its Young's modulus. The sample size was 250 mm square, having a nominal thickness of 40 mm. The nominal density of the sample was 520 kg/m3. An Instron compression machine was utilised, with a load cell of 10 kN capacity. The loading plates were: 100 mm top compression plate, 300 mm bottom compression plate.

The test protocol was as follows;

1. Compression rate set at 5 mm/minute.
2. A small seating load of 50N was applied to the sample at the start of the test to ensure good contact, and the deformation gauge set to 0 mm.
3. The sample was subjected to two pseudo-static load cycles. A further cycle was used to evaluate the effects of a maintained load (creep) test.
   a. The sample was compressed up to the pre-set load of 2500N. The load was then removed and the sample examined for any signs of damage.
   b. The sample was compressed up to the pre-set load of 5000N. The load was then removed and the sample examined for any signs of damage.
   c. The sample was compressed to the pre-set load of 2500N and the load maintained for a period of 7 hours.
4. The samples were observed during the compression and the real-time Load vs Deformation behaviour observed.

The vertical strain at 2500N was estimated at approximately 10%. The gradient of the force versus deformation graphs permitted an estimate of the sample (spring) stiffness to be in the range of 600 kN/m. The stress/strain data suggests an (elastic) stiffness modulus of approximately 3.2 MPa.

The test was repeated with a 24 mm thick sample having the same composition as that of the previous sample. This had a nominal density of 490 Kg/m3. The vertical strain at 2500N was approximately 17% and the gradient of the force versus deformation graph permitted an estimate of the sample (spring) stiffness to be in the range 570 kN/m. The stress/strain data suggests an (elastic) stiffness modulus of approximately 2 MPa.

Operation

Operation of the sports field **1** will now be described with reference to FIGS. **1** and **2**. During use, rain water falling on the sports field **1** percolates through the artificial turf layer **6** into the water distributing layer **4**. The level surface of the substrate **2** allows the water to distribute across the whole of the sports field **1**, assisted by capillary action within the water distributing layer **4** and its open structure. The inlets **18** to the drain channel **16** are at the height of the bitumen coating **12** at the upper surface of the substrate **2** and allow the water to escape into the drain channel **16** from where it can flow through the outlet **30** to the chamber **28** and through the valve flow gate **32** to the storm water drainage system **34**. If desired, the valve flow gate can be closed, whereby water will back-up within the drain channel **16** until it reaches the level of the inlets **18**. Any further rainfall will remain within the containment **24**. The valve flow gate **32** may be controlled to keep the level of water at a predetermined level within the water distributing layer **4** or may be set to slowly release it into the storm water drainage system **34** to allow for attenuation.

During warm periods, additional water may be introduced into the water management facility **26** through the water supply pipe **36** to cause the water level in the containment **24** to rise above the level of the water distributing layer **4**. By increasing the water level to completely or partially flood the artificial turf layer **6**, the sports field **1** can be quickly cooled. Subsequently draining the water from the containment **24** allows the designated sport to be practiced, while the artificial turf layer **6** may continue to evaporate moisture thereby keeping the sports field **1** cool. It is noted that although not illustrated in the present design the water management facility **26** may be provided with a buffer reservoir having a capacity equal to the size of the containment or at least the part of the containment above the water distributing layer **4**, allowing this portion of the sports field **1** to be filled and emptied prior to play commencing.

Thus, the invention has been described by reference to certain embodiments discussed above. It will be recognized that these embodiments are susceptible to various modifications and alternative forms well known to those of skill in the art. In particular, the arrangement of sub-base construction and its design may be based on local geological conditions and materials available. Thicknesses and ratios of granulated materials of the water distributing layer, kerb size and shape, drainage hole frequency, size and shape water inlet and outlet points attenuation and water flow rates, and water input and extraction facilities may all be dependent on performance requirements and may be distinct from the schematically illustrated design.

Many modifications in addition to those described above may be made to the structures and techniques described herein without departing from the spirit and scope of the invention. Accordingly, although specific embodiments have been described, these are examples only and are not limiting upon the scope of the invention.

The invention claimed is:

1. A sports field comprising:

a stable, impermeable substrate;

a water distributing layer provided over the substrate;

an artificial turf layer over the water distributing layer;

a bund defining a perimeter of the sports field and extending from the substrate to above the height of the artificial turf layer to form an impervious containment having a volume above the water distributing layer;

a drain channel having inlets at a height to communicate with the water distributing layer;

a water management facility comprising a buffer reservoir chamber having a capacity equal in volume to at least said volume above the water distributing layer, the buffer reservoir chamber connected to the drain channel and to a valve flow gate and a pump such that water can flow from the water distributing layer into the drain channel and such that water can flow from the drain channel into the water distribution layer to fill the impervious containment with water to a depth sufficient to immerse the artificial turf layer over the full area of the sports field.

2. The sports field according to claim **1**, wherein the drain channel is integrally formed with the bund.

3. The sports field according to claim **1**, wherein the water management facility is arranged to control the height of the water within the drain channel to determine whether water flows from the water distributing layer into the drain channel or vice versa.

4. The sports field according to claim **1**, wherein the drain channel extends below and above the water distributing layer.

5. The sports field according to claim **1**, wherein the stable impermeable substrate comprises a stabilised soil substrate.

6. The sports field according to claim **1**, wherein the stable impermeable substrate comprises an impervious membrane or coating.

7. The sports field according to claim **1**, wherein the upper surface of the water distributing layer is substantially horizontal, preferably having no gradient greater than 1 in 100 and optionally less than 1 in 300.

8. The sports field according to claim **1**, wherein the water distributing layer comprises recycled plastic granules and a binder and has a Young's modulus in compression of between 1MPa and 10 MPa.

9. The sports field according to claim **1**, wherein the water distributing layer has a void ratio of between 20% and 70%, optionally around 45%.

10. The sports field according to claim **1**, wherein the water distributing layer has a depth of between 10 mm and 100 mm, optionally around 40 mm.

11. The sports field according to claim **1**, further comprising a resilient layer provided between the water distributing layer and the artificial turf layer.

12. The sports field according to claim **1**, wherein at least the upper extremity of the bund comprises resilient material.

13. A method of constructing a sports field comprising:

providing a stable, impermeable substrate;

providing a water distributing layer over the substrate comprising recycled plastic granules with a void ratio of between 20% and 70%;

installing an artificial turf layer over the water distributing layer;

forming a bund defining a perimeter of the sports field and extending from the substrate above the top of the water distributing layer and to at least the height of the artificial turf layer to form an impervious containment wherein the bund comprises hollow curb-stones, forming

an integral drain channel communicating with the water distributing layer such that water can flow from the water distributing layer into the drain channel and such that water can flow from the drain channel into the water distribution layer to fill the impervious containment with water to a depth sufficient to fill the void spaces within the water distributing layer and immerse at least part of the artificial turf layer over the full area of the sports field.

14. The method of claim **13**, wherein providing the substrate comprises stabilisation of the existing on-site soil to a CBR of greater than 15 and preferably to a depth of at least 100 mm.

15. The method of claim **13**, wherein forming of the substrate comprises providing an impermeable membrane or coating over a stabilised base.

16. The method of claim **13**, wherein providing the water distributing layer comprises in-situ laying of a semi-fluid mass comprising recycled plastic granules and a binder, levelling the semi-fluid mass and allowing the semi-fluid mass to solidify to form a rigid porous layer.

17. The method of claim **13**, wherein providing the water distributing layer comprises paving the substrate with preformed porous slabs of recycled plastic granules.

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