



Manager's Guide to Natural Grass Football Pitches

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Manager's Guide
to Natural Grass
Football Pitches

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1 Introduction

The aim of this guide is to provide background information to assist decision-making and ensure that football pitches are constructed and maintained to a good standard. The guide has been developed primarily for managers and administrators so that they are aware of the main stages in the development of football pitches and the maintenance resources that are necessary to sustain a good quality playing surface.

The main characteristics of the playing surface that need to be achieved are:

- Suitable gradient and free from dips and hollows
- Well drained
- Good grass cover of desirable grass species
- Firm and stable to give good playing characteristics
- Appropriate pitch markings with a good visual appearance

2 Using this guide

Methods used for pitch construction, grass selection and the management of pitches are very strongly influenced by the quality of the pitch that is required, the resources that are available and the climate of the area concerned. Accordingly, this guide has been prepared to include two standards of pitch provision and nine main climate zones. It is important to have a clear idea of the type of facility that is being developed and the main climate constraints in the area.

2.1 Standard of facility

The quality of the pitch depends largely on the resources that are available for both construction and maintenance. Two different grades of playing surface are included:

- General-standard pitches: these are intermediate-quality pitches used primarily for club teams, recreational play and training facilities.
- Highest-standard pitches: these are appropriate when a very high standard of playing surface is required mainly for professional and international sport. Under these circumstances it is important to eliminate risks of poor playing conditions or cancellation, particularly associated with poor weather conditions, e.g. heavy rainfall or ice and snow.

General-standard pitches are often constructed using the existing soil on the site. The main priorities are usually upgrading the drainage, improving surface levels as well as the resources in terms of equipment, fertiliser, plant protection products, etc., and ensuring that there are enough ground staff who have been trained and have acquired the relevant turf management skills.

Highest-standard pitches will usually have a full construction profile with a sand-dominated rootzone and may include such features as turf reinforcement, growth lights and a vacuum/air ventilation system, especially in difficult growing environments within stadiums.

2.2 Climate area

The nine climate zones featured in this guide are as follows:

- Cool, maritime
- Temperate, maritime
- Cool, continental
- Mediterranean type, dry summer subtropical
- Continental, transition
- Subtropical
- Tropical, high rainfall
- Tropical, seasonal rainfall
- Tropical, semi-arid or arid

The map in Figure 1 shows the locations of the main climate zones. It is important to note, however, that additional factors may influence the grasses that should be selected as well as construction and management issues. In particular, the map has been simplified in terms of mountainous areas where temperatures are generally lower and rainfall often higher. Accordingly, it may be necessary to look at more than one of the guideline sections to determine which is most suited to a specific area.

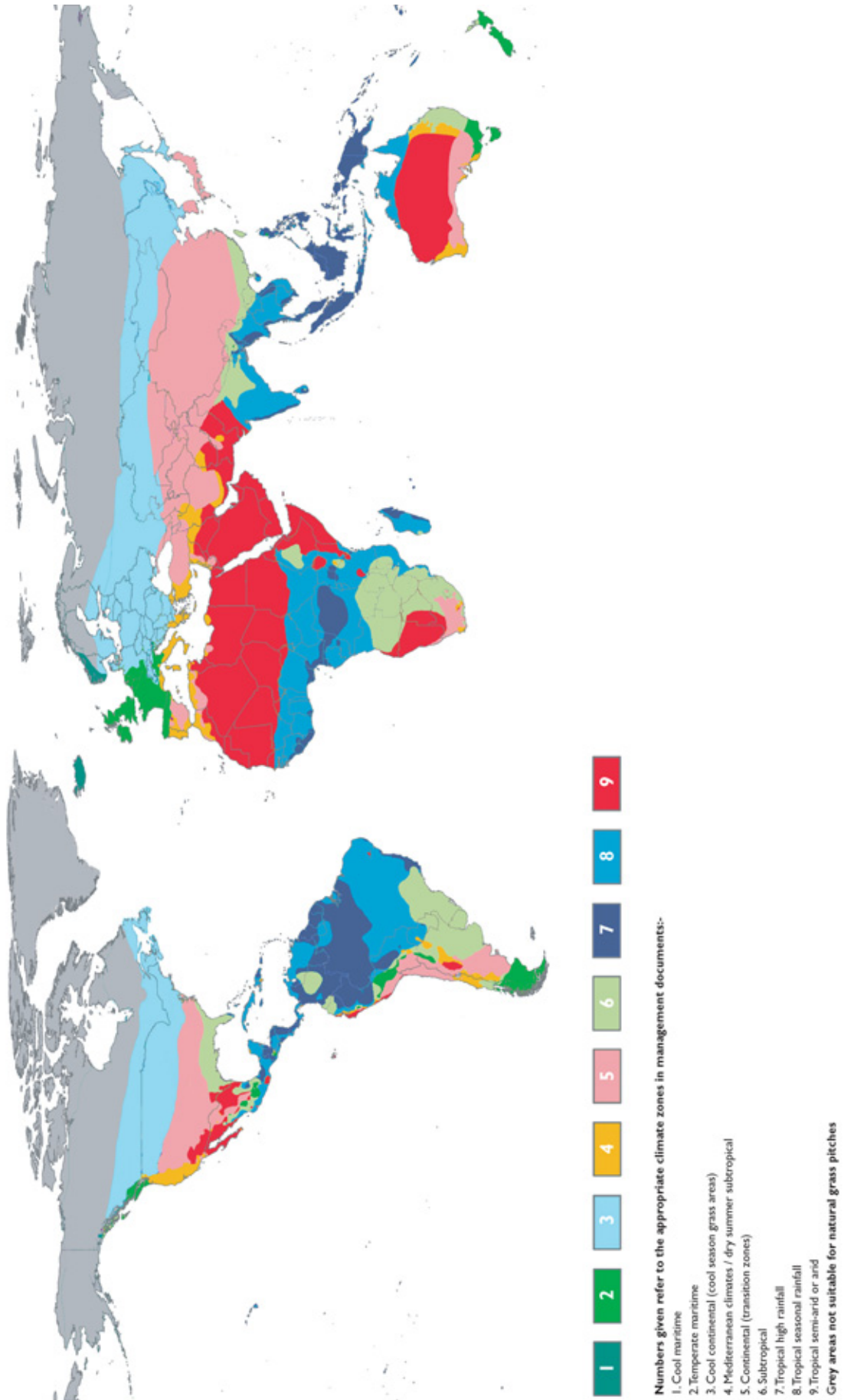


Fig. 1: Climate map

2.3 Specialist advice

This guide is intended to focus on the most important issues that need to be considered in developing and maintaining pitch facilities. However, advice from a reputable sports turf consultant or specialist is often essential, particularly to: (1) determine construction requirements, (2) ensure that construction work is carried out to appropriate standards and using suitable materials, and (3) provide a good quality maintenance programme for the pitch.

2.4 References

Additional information on pitch construction can be found in the following publications:

FIFA (2011). Football Stadiums. Technical recommendations and requirements (5th edition). Available on www.FIFA.com

FIFA (2012). Natural Grass Pitch Reinforcements. FIFA Guidance notes.

This information is particularly relevant to the construction and management of highest-standard facilities.

3 Glossary

Term	Description
Aeration	Operations which are carried out to improve turf by physical methods to increase drainage and air exchange and to encourage better root development
Annual meadow-grass	Cool-season grass species (<i>Poa annua</i>) usually considered to be a weed species
Bermudagrass	Type of warm-season grass (<i>Cynodon</i> species)
Boom sprayer	Machine with a line of nozzles on extending arms for spreading liquid chemicals on turf
Brush	A device consisting of bristles held in a suitable frame used to sweep the grass
Clay	Soil particles smaller than 0.002mm in diameter – clay-rich soils usually have poor drainage characteristics and are water retentive
Cutting height	The height above ground level at which the sward is cut
Cylinder mower	A grass mower where the cutting blade moves in a vertical plane and cuts due to the action of the cylinder blades against the sole plate
Disease	A pathological condition, usually as a result of a fungal infection often associated with environmental stress, which affects the quality of the grass plant
Drag mat	A flexible steel mat which is pulled along to work on top dressings, more particularly on undulating turf surfaces
Drainage system	A network of drains to remove excess water from a pitch
Fertiliser analysis	The percentage of nitrogen, phosphorus, potassium and other plant nutrients found in a fertiliser
Fungicide	Any chemical which controls or destroys the growth of a fungus
Grass	Any of various plants having slender leaves characteristic of the grass family
Gravel	Rock fragments or small pebbles typically 2-10mm in diameter
Hollow tine	A form of aeration in which a cylindrical tine is used to remove cores from the soil
Insects	Small arthropod animals of the class Insecta, having an adult stage characterised by three pairs of legs and a body segmented into head, thorax, and abdomen and usually having two pairs of wings, including flies, crickets and beetles
Irrigation	The controlled application of water to turf

Term	Description
Kentucky bluegrass	Cool-season grass species (<i>Poa pratensis</i> , also called smooth-stalked meadow-grass in some countries)
Line marker	Machine for marking white lines on a pitch
Mower	Grass-cutting machine
Peat	Material consisting largely of undecomposed or partially decomposed organic material accumulated under conditions of excessive moisture; often used to improve water and nutrient retention
Perennial ryegrass	Cool-season grass species (<i>Lolium perenne</i>)
Pest	Insects, grubs or other soil organisms that may cause damage to the grass plant
Pesticide	Any substance or mixture of substances intended for preventing or controlling any unwanted species of plants and animals and which includes any substances intended for use as a plant growth regulator, defoliant or desiccant, including fungicides, herbicides and nematicides
Pipe drain	Trench containing a drain pipe backfilled with a suitable type of gravel
Renovation	Repair of an area of turf by cultivating, re-levelling and reseeded, particularly carried out at the end of the playing season
Roots	The underground portion of a plant that serves as support, draws minerals and water from the surrounding soil, and sometimes stores food
Rootzone	Mix of sand and soil or sand and organic matter used as the growing medium for the grass plant
Rotary mower	A powered mower that cuts turf through the high-speed impact of blades rotating in a horizontal cutting plane
Sand	Granular mineral materials ranging from 0.05mm to 2mm in diameter, regularly used on pitches because of their good drainage and other physical properties
Scarifier	Machine for cutting through horizontal growth and thatch with a raking or vertical cutting action
Seashore paspalum	Warm-season grass species (<i>Paspalum vaginatum</i>)
Seed	The reproductive structure of a plant containing an embryo, a food supply and a protective coat, and used for the establishment of grass

Term	Description
Silt	Intermediate-size fine particles of between 0.002mm and 0.05mm in diameter – silt-rich soils tend to be water retentive and have poor drainage characteristics
Slit drainage	Drainage system in which a series of sand- and/or gravel-filled channels link the pitch surface with porous, aggregate over-pipe drains, allowing excess surface water to bypass the soil
Slit tine	Knife or bladed tine
Smooth-stalked meadow-grass	Cool-season grass species (<i>Poa pratensis</i> , also called Kentucky bluegrass in some countries)
Sod	Strips of turf grasses usually with adhering soil used in vegetative planting (also called turf in some countries)
Soil	The natural medium for plant growth consisting of mineral particles mixed with organic matter
Solid tine	Spike or blade used to create holes in the turf surface during aeration work
Sowing	Adding seeds to the soil to produce new grass
Spiker	Machine used to create aeration holes in the turf
Sprig	Vegetative material (a stolon, rhizome, tiller or combination) used to establish turf usually for warm-season grass species
Stone	Large particles of mineral matter or rock typically greater than 10mm in diameter
Sweeper unit	Machine usually with a rotating brush and collector
Tall fescue	Cool-season grass species (<i>Festuca arundinacea</i>)
Thatch	A layer of intermingled dead and living shoots, stems and roots that develops between the zone of green vegetation and the soil surface
Turf	(1) The grass-covered surface of the ground growing within the upper soil layer (2) Strips of turf grasses usually with adhering soil used in vegetative planting (also called sod in some countries)
Vacuum unit	Suction device mainly used to lift grass clippings and other debris from the surface of the pitch
Verticutting	Use of a machine with vertically rotating blades that cut into the turf to remove thatch or cut stolons
Verti-Drain	A tractor-drawn turf aerator which can break up deep compaction by means of tines
Weeds	Unwanted grasses or broad-leaved plants whose negative values outweigh the positive values in a given situation

4 Typical problems on football pitches



Poor drainage leading to loss of grass cover



Poor surface levels, poor drainage and weed invasion



Poor grass establishment



Grass loss through heat stress and disease



Weed invasion which will affect consistency, pitch appearance and playing quality



Weed grasses and broad-leaved weed



Irrigation system with poor overlapping of sprinklers



Uneven watering affecting grass density and playing performance



Uneven fertiliser application leading to poor appearance and uneven grass growth



Excessive use and poor surface levels in the goalmouth

5 Pitch construction

- A poorly constructed pitch will reduce the number of games that can potentially be played, can be expensive to maintain and will affect the quality of play.
- A poorly constructed pitch will increase the risk of match cancellation in adverse weather.
- It is important that the pitch is constructed to an appropriate standard for the intended level of play.

5.1 Construction planning

The most important aspects of construction planning include:

- Determination of soil characteristics of both the topsoil and the underlying layers, although for many higher-grade pitches new drainage and rootzone materials are brought to the site.
- Assessments are needed to determine whether underlying stone and rock may be important factors influencing pitch design.
- Contours of the site should be assessed to determine whether significant adjustment of surface levels will be required.
- Assessment of a suitable outfall for drainage: a ditch, stream or access to the public drainage system will need to be used as an outfall for pitch drainage (for many new facilities, planning consents may be required).
- The presence of existing services on the site needs to be identified, which will include electricity and water supply for irrigation but also the location of existing pipework that needs to be avoided during any construction or drainage work.
- Pitch layout in relation to surrounding features and correct alignment of the pitch is needed to reduce problems of low sun angles, particularly in the evening.
- Expected levels of usage in terms of hours of use for matches and training sessions and the required standard of the facility in relation to the type of teams using the pitch must be understood.
- The potential budget that is available for pitch construction.
- Timelines for construction or drainage work, determination of the length of the grass establishment period and the time before the facility is likely to be available for use.
- Resources in terms of staff and equipment available to maintain the facility.

For high-quality pitches that are constructed within large stadiums, several additional factors may need to be considered:

- There may be other types of use and the design should be carried out in full knowledge of all potential uses of the stadium.
- Many stadium pitches used for professional football have to be developed in the context of an existing facility – this must be considered in the design work.
- In larger stadiums there can be significant amounts of shade and restricted air movement, with both factors having significant implications for grass quality. Assessment of the environmental effects of the stadium structure is needed at the design stage and this typically includes analysis of shade patterns at different times of the year and assessment of potential air movement.
- The effects of shade within a stadium means that frost or snow will clear more slowly and the need for undersoil heating or pitch covering needs to be evaluated. There may also be specific requirements from the football authorities with respect to pitch protection that need to be addressed.
- For international sport at major stadiums, it is important to consider the need for a vacuum/ventilation system to allow fully controlled management of subsurface air and water movement and enhanced heat transfer or cooling from the underlying layers to the grass surface.
- Most stadium events are at fixed times to accommodate both spectators and television and the risk of cancellation as a result of adverse weather must therefore be considered. The budget for pitch construction and subsequent maintenance must be determined in relation to these risks.

5.2 Construction methods

In many cases, a slight cross fall or crown to the pitch will be useful to help the removal of excess water. This is particularly important in high rainfall areas.

On many sites, surface levels may not be suitable for good-quality football pitches. Minor adjustments of up to +/- 50mm may be achieved by cultivation and grading, but larger changes in levels need to be addressed by removal of the topsoil and re-levelling of the base using the cut and fill method before the topsoil is returned. It is essential that the base is adequately consolidated to ensure that future settlement issues are not a problem.

The construction method that is selected must be considered in relation to climate and local soils, anticipated usage levels, the quality of the pitch that is required and the budget available. This is discussed in more detail in the sections covering the various climate regions. Representative cross-sections for some of the main methods of construction are given below.

5.2.1 Basic pipe drainage

Trenches are excavated typically to a depth of around 600mm, but may vary in depth depending on site circumstances. A pipe is placed in the trench base and the trench is backfilled with gravel or other suitable aggregate before being capped off with sand and a suitable rootzone mix.

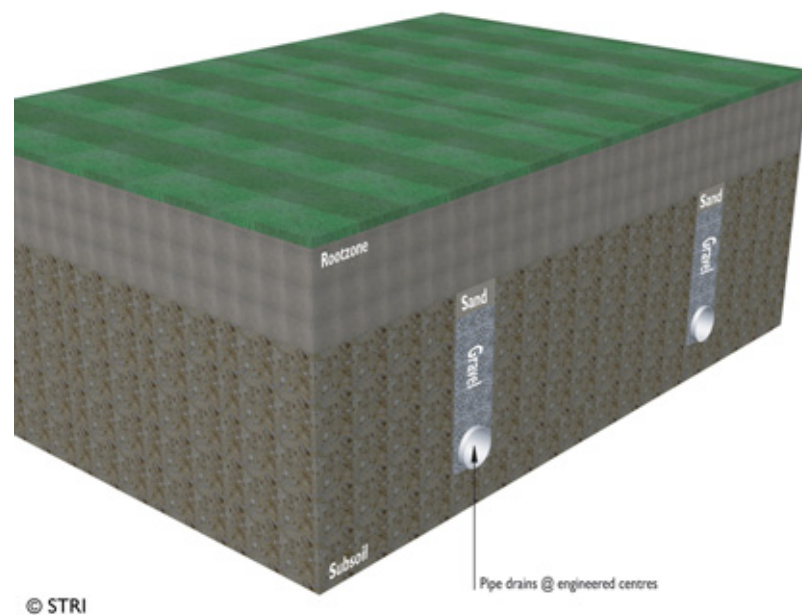


Fig. 2: Profile of a pipe-drained pitch

5.2.2 Pipe and slit drainage

Supplementary slit drainage can improve the performance of a pipe-drained system. The spacing of the slits is variable, but they can be as close as 0.6-1.0 metres. The function of the slits is to intercept surface water and carry it down to the porous backfill of the drain trenches, bypassing the soil rootzone which may be of low permeability. Slits are normally installed in conjunction with heavy sand dressing to prevent the slits being capped by soil.

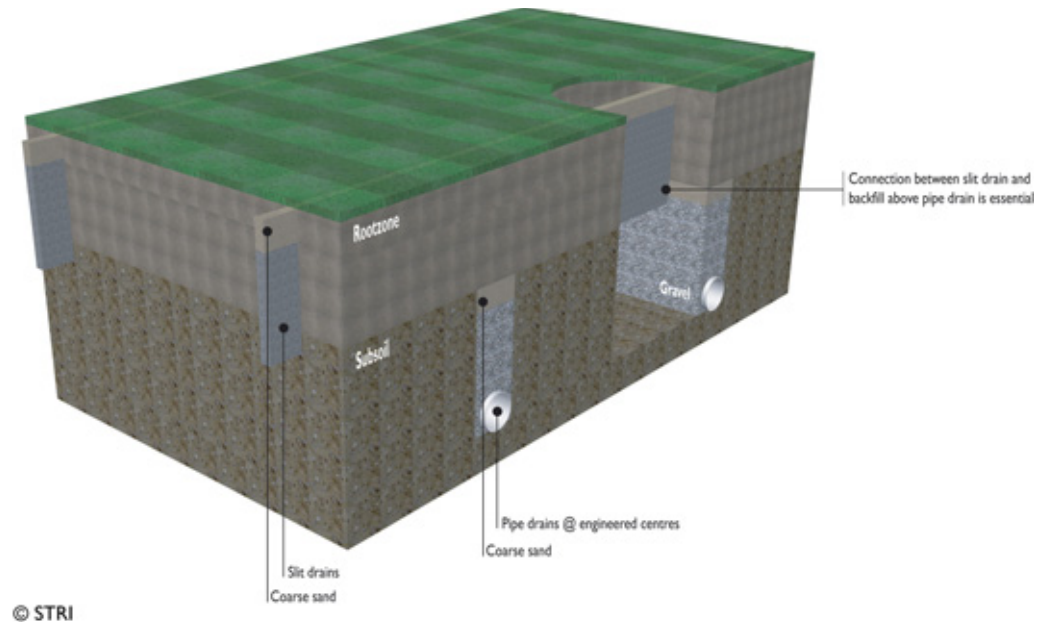


Fig. 3: Profile of a pitch with pipe and slit drains

5.2.3 Sand carpet construction

This form of pitch retains the existing soil, but the drainage and physical properties of the surface layer are improved by using carefully selected sand or a sand-dominated growing medium.

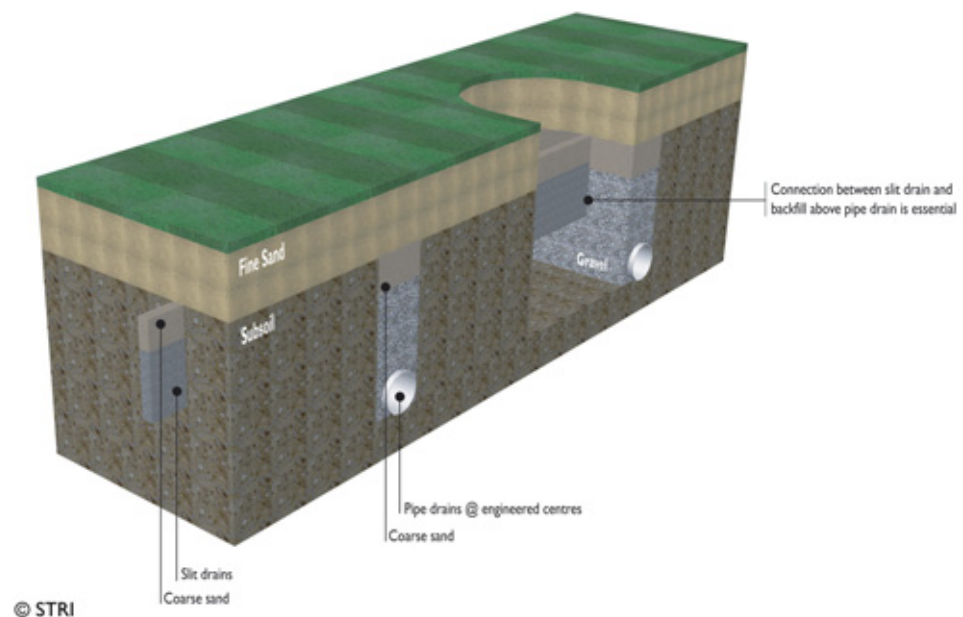


Fig. 4: Profile of a sand carpet pitch

5.2.4 Soil over a drainage layer

This method includes a base layer formed from gravel or another suitable drainage aggregate, but uses soil as the main growing medium. However, it is often necessary to improve the characteristics of the soil layer by slit drainage or amelioration with sand.

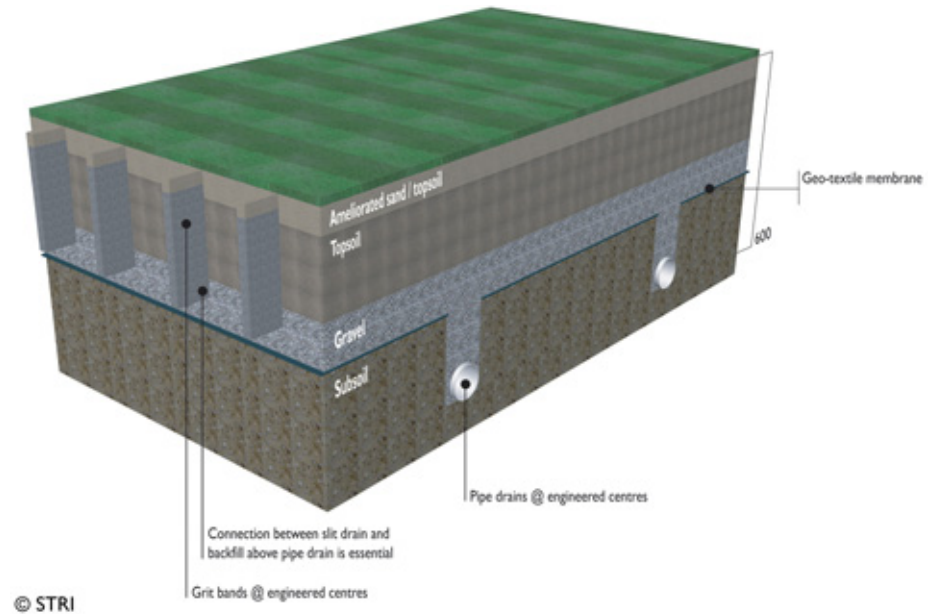


Fig. 5: Profile of a pitch with a soil rootzone over a gravel drainage layer

5.2.5 Sand-dominated rootzone over a gravel drainage layer

This approach is often used when good drainage is essential, but can also be useful in dry climates as water tends to be held in the rootzone layer and does not move down into the gravel unless there is either heavy rainfall or excessive irrigation. The selection of the materials used in the different layers is critical to the success of this type of construction.

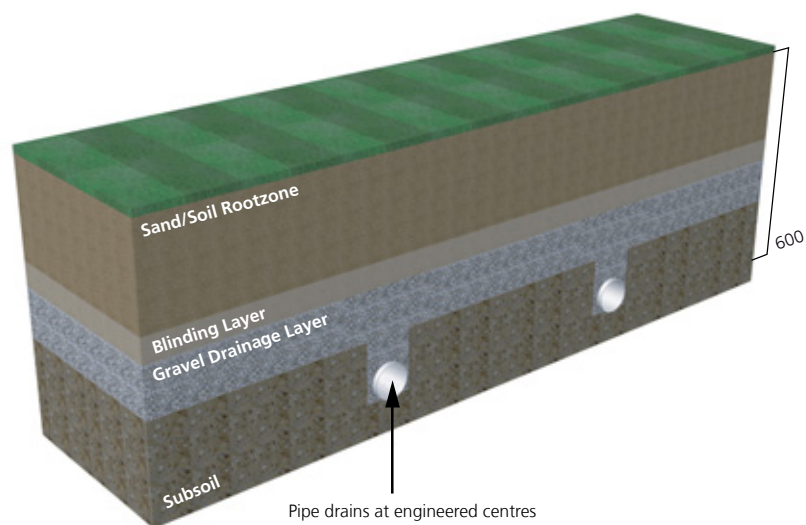


Fig. 6: Profile of a pitch with a sand-dominated rootzone over a gravel drainage layer.

6 Grass selection

The grasses that are chosen for a pitch must be suited to the area where the pitch is built, must provide a hard-wearing sward and must be capable of providing the required playing performance and presentation for the pitch.

Grass selection is very dependent on the climate of the area and is therefore treated in more detail in the sections covering individual climate areas. However, there are two main groups of grasses that vary considerably in their basic biology and climate adaptation:

- Cool-season grasses are adapted, as the name suggests, to the cooler climate regions and examples that are regularly used on football pitches include perennial ryegrass (*Lolium perenne*), smooth-stalked meadow-grass/Kentucky bluegrass (*Poa pratensis*) and tall fescue (*Festuca arundinacea*).
- Warm-season grasses are adapted to tropical areas and examples include bermudagrass (*Cynodon species*), zoysia species (mainly *Zoysia japonica* and *Zoysia matrella*) and seashore paspalum (*Paspalum vaginatum*).

Each grass type has particular characteristics that make it more suitable in certain climate areas such as tolerance to heat or cold, drought resistance or disease resistance. There has also been extensive grass breeding work to improve varieties and it is important that cultivars of each species are selected to improve wear tolerance and are well adapted to the site conditions.

There are significant problems in grass selection in some parts of the world where there is a relatively wide range of temperatures. In these climate zones, cool-season grasses are poorly adapted to summer conditions when high temperatures, water availability and possibly salt accumulation may be significant issues. On the other hand, warm-season grasses are intolerant of colder winter conditions and tend to go brown and dormant. Under these circumstances, it is often essential to oversow the main warm-season grass with a cool-season species before the onset of winter. The main areas affected by this are the continental transitional zone climates and some Mediterranean/dry summer subtropical climates.

7 Maintenance

There are a number of essential operations that need to be carried out on a pitch to maintain the quality of the grass surface and to ensure that the underlying soil or root-zone material will support root development and give a well-drained and stable playing surface.

7.1 Mowing

Purpose

The purpose and advantages of mowing are: (1) to ensure that the grass is at a suitable height for matches; (2) regular cutting improves the density of the grass sward; (3) the mowing lines are important in the presentation of pitches; and (4) mowers can also be used to lift surface debris resulting from games.

Equipment

A wide range of equipment is available. The main categories are based on these methods of cutting: (1) cylinder mowers cut the grass using a rotating reel of sharpened blades cutting against a fixed bottom blade; (2) rotary mowers use a rotating horizontal blade; and (3) flail mowers cut the grass through the vertical rotation of splayed blades. For the different types of mowers there can be pedestrian versions, with the operator walking behind the machine, and either tractor-mounted or ride-on machines. It is essential that cutting blades are properly set up to give a good-quality cut and that the sharpness of the blades is maintained.



Ride-on cylinder mower



Rotary mowers being used to lift debris

7.2 Fertiliser application

Purpose

Fertiliser is applied in order to: (1) provide a range of essential nutrients that support growth, thus giving a strong, wear-resistant sward, and to help recovery after damage; (2) improve the colour of the grass as this can be an important element of pitch presentation.

Materials and equipment

There is a wide range of fertiliser types, with the most important nutrients being nitrogen, phosphorus and potassium, but other elements and micronutrients may also be needed.

Accurate and uniform application is essential and fertiliser is mainly applied in powdered or granular form using a rotary spreader or in liquid form using a sprayer.



Pedestrian fertiliser spreader



Fertiliser spreading with tractor equipment

7.3 Irrigation

Purpose

Irrigation is required: (1) to provide the grass plant with water to support growth; (2) to reduce the hardness or firmness of the surface layer; (3) to improve the stability of sand-dominated rootzones which may become too loose if allowed to dry out; (4) to influence the speed of the ball over the playing surface; (5) to water in chemicals and other materials applied to the pitch; and (6) irrigation may be needed in arid areas to wash excess salts out of the soil.

Equipment

A wide range of equipment is available for watering pitches and includes, in a general order of increasing effectiveness in terms of uniformity of watering systems, hand-held hose pipes, portable rotary and oscillating sprinklers, travelling sprinklers, water cannon and pop-up irrigation systems.



Pop-up irrigation



Rotary sprinkler, but note that regular movement is essential to get effective coverage

7.4 Sand application and top dressing

Purpose

Sand and top dressing is applied to pitches to: (1) improve surface levels; (2) dilute fine mineral and organic matter that accumulates at the surface of the pitch; (3) help drainage; (4) provide a firmer playing surface; and (5) stabilise channels created by aeration work.

Materials and equipment

In cooler and wetter climates pure sand is normally used, but there are very specific requirements. If the sand is too fine, it will tend to hold water and may impede drainage; if it is too coarse, there will be potential problems of stability, complaints from the players and possible damage to mowers. In hotter, drier climates a mix of sand with soil or organic matter is often used as this can help water and nutrient retention.

Where resources are limited, sand and top dressing can be applied manually, e.g. using a spade followed by a brush or drag mat to distribute the material, but preferred equipment includes rotary and drop spreaders as these will give much more uniform application.



Sand spreader

7.5 Scarification/verticutting

Purpose

The scarification process is needed to: (1) remove excess organic matter from the sward to improve growth; (2) cut any lateral or creeping grass growth for a denser, stronger sward; (3) improve the firmness and traction properties of the grass; and (4) open up the surface or weaken unwanted, coarser grasses before overseeding.

Equipment

There is a wide range of scarification equipment, varying from rake attachments and harrows to powered reel-type scarifiers with rotating blades that cut into the turf surface.



Scarifier



Cylinder mower with verticutting cassette

7.6 Brushing and removal of surface debris

Purpose

Pitches are brushed to: (1) remove grass cuttings and other debris from the playing surface; (2) stand the grass up after matches to give better growing conditions and reduce the risk, for example, of algae forming on the surface; (3) ensure that the grass is upright, allowing more uniform and effective cutting; (4) spread or work sand and top dressing into the surface; and (5) disperse dew that may form on the pitch.

Equipment

Equipment can vary from drag brushes to powered suction units. Rotary mowers are also often used to lift surface debris and to make the grass plant stand upright.



Hand brush



Tractor-mounted brush

7.7 Aeration

Purpose

Aeration is required to: (1) create a network of holes in the surface of the pitch to improve water infiltration and air exchange; (2) relieve compaction in the soil, promoting better root development; (3) remove fine material from the surface layer and create holes within the pitch that can be stabilised by sandy materials; (4) control thatch; and (5) modify the firmness characteristics of the playing surface.

Equipment

There is a very extensive range of equipment depending on the depth of penetration required and the type of operation needed. In the simplest case hand forks can be used, but there is also a range of powered equipment varying from drum-type aerators, punch-action machines, drills and machines that inject compressed air to lift and fissure the soil. Some of the larger and more powerful machines include a heave function to lift the soil and relieve compaction.

There are also various types of tine, but the main division is between: (1) solid tines, which are usually either needle-like or bladed/knife-type, that make holes within the soil without removing any material; and (2) hollow tines that take cores of soil and organic matter, which are left on the surface and can then be removed or broken up and reintegrated into the surface layer.



Deep aeration with solid tines



Hollow-core aeration and core collection

7.8 Line-marking

Purpose

The process of line-marking is an essential part of pitch preparation which ensures that lines are correctly located in order to conform to the Laws of the Game. Clear and well-defined lines are important in pitch presentation.

Materials and equipment

A range of marking compounds are available and it is essential that they are approved for use on pitches for player safety reasons. The long-term effects of any marking materials on the grass must also be considered.

Where no other equipment is available, lines can be painted by hand using a brush or roller. However, a line marker is normally used, with the most common types being wheel-to-wheel transfer, combinations of wheels and belt or spray-type line markers.



Wheel-type line marker



Jet-type line marker

7.9 Weeds, diseases and pests

Control requirements

Most areas of turf can be subject to invasion by weeds and to damage by disease or pests. The selection of the correct grasses and good management practices can help to minimise problems with weeds, disease and pests. Hand-weeding can be used to remove some weed types but is not effective against all weeds, especially those with underground plant material (e.g. roots or tubers).

Materials and equipment

Where treatment becomes necessary, the problem must first be correctly identified and an appropriate herbicide, fungicide or pesticide must then be used. It is essential to note that there are strict regulations concerning the use of herbicides, fungicides and pesticides on turf and all relevant legislation covering the materials used and the method of application must be complied with at all times. The application rate used is very important and therefore most plant protection products should be applied with a properly calibrated sprayer.



Spraying equipment

7.10 Maintenance equipment for general-standard pitches

A list of the main equipment requirements and possible options is given below. The best choice for any site will depend on several factors, including the required standard of the pitch, the nature of the pitch and any specific problems that need to be addressed, staffing levels, and the budget available.

Mowers	<ul style="list-style-type: none"> • Pedestrian cylinder mowers for pitch preparation if staffing levels are sufficient • Ride-on triple mower with cylinder blades • Sometimes ride-on rotary mowers are used, although the quality of the cut and presentation is not as good as when cylinder mowers are used. • Rotary mowers are useful for lifting debris from the pitch and helping to make the grass stand upright after matches.
Aeration equipment	<p>Shallow aerator to about 100-150mm</p> <ul style="list-style-type: none"> • Punch-action pedestrian spiker (e.g. with 8-10mm and 15-18mm solid tines and 12mm hollow tines) • Tractor-mounted punch-action aerator • Tractor-mounted drum-type aerator/slitler <p>Deep aeration</p> <ul style="list-style-type: none"> • Deep spiker capable of reaching depths of 200mm or more, often hired from a contractor
Sprayer	<ul style="list-style-type: none"> • Tractor-mounted sprayer or self-contained unit for application of liquid fertiliser or plant protection products
Sweeper	<ul style="list-style-type: none"> • Sweeper unit with a powered brush and collector • Sometimes a vacuum sweeper is used or a rotary mower.
Power unit for attachments	<ul style="list-style-type: none"> • Tractor with turf tyres
Brush and rake units	<ul style="list-style-type: none"> • Drag brush • Tractor-mounted brush • Tractor-mounted rake
Fertiliser spreader	<ul style="list-style-type: none"> • Pedestrian unit • Tractor-mounted unit
Tractor-mounted seeder	<ul style="list-style-type: none"> • Often hired when needed or available between a number of sites
Tractor-mounted sand spreader	<ul style="list-style-type: none"> • Often hired when needed or available between a number of sites
Line marker	<ul style="list-style-type: none"> • Wheel-to-wheel transfer marker • Pressure-jet line marker
Assorted hand tools	<ul style="list-style-type: none"> • Hand fork, drag brush, hand rakes, lutes, turf plugger

7.11 Maintenance equipment for highest-standard pitches

The type of equipment required for high-quality pitches will vary and there may be more emphasis on pedestrian operations, particularly in difficult stadium environments, to avoid damage that can occur with tractor-mounted equipment under poor growing conditions.

Mowers	<ul style="list-style-type: none"> • Pedestrian cylinder mowers for match preparation and pedestrian rotary mowers for lifting debris – preferred option when high-quality surfaces are required, especially if there are environmental issues within the stadium • A cassette system will offer flexibility for verticutting and surface aeration. • Ride-on triple mower with cylinder blades – may be appropriate on intermediate-grade pitches if turning areas are sufficient
Aeration equipment	<p>Shallow aerator to about 100-150mm</p> <ul style="list-style-type: none"> • Punch-action pedestrian spiker (e.g. with 8-10mm and 15-18mm solid tines and 12mm hollow tines) – preferred options where high-quality surfaces are required • Tractor-mounted punch-action aerator • Tractor-mounted drum-type aerator/slitter <p>Deep aeration</p> <ul style="list-style-type: none"> • Deep spiker capable of reaching depths of 200mm or more, often hired from a contractor
Sprayer	<ul style="list-style-type: none"> • Tractor-mounted sprayer or self-contained unit for application of liquid fertiliser or plant protection products
Fertiliser spreader	<ul style="list-style-type: none"> • Pedestrian unit • Tractor-mounted unit
Tractor-mounted seeder	<ul style="list-style-type: none"> • Often hired when needed or available between a number of sites
Tractor-mounted sand spreader	<ul style="list-style-type: none"> • Often hired when needed or available between a number of sites
Line marker	<ul style="list-style-type: none"> • Wheel-to-wheel transfer marker • Pressure-jet line marker
Assorted hand tools	<ul style="list-style-type: none"> • Hand fork, drag brush, hand rakes, lutes, turf plugger
Power unit for attachments	<ul style="list-style-type: none"> • Tractor with turf tyres
Brush and rake units	<ul style="list-style-type: none"> • Drag brush • Tractor-mounted brush • Tractor-mounted rake

7.12 Staffing levels

It is important that there are sufficient numbers of staff available to maintain the facility and that they have received the necessary training to do the work effectively. Staffing levels will be influenced by the amount and quality of equipment available for pitch maintenance and whether any of the work is being carried out by contractors. Staffing levels can also be influenced by the nature of the work that is carried out on the site, for example if the ground staff also have responsibilities of looking after changing rooms or the stadium infrastructure.

8 Usage levels

Usage levels are very dependent on the quality of the construction, the grass species being used and the standard of maintenance. The amount of use that a pitch can receive will also vary at different times of the year depending on temperatures, rainfall and growth rates of the grass.

- When growth is poor, usage levels of only two to three hours per week may be possible, particularly if soil properties are unfavourable. On the other hand, in good growing conditions with a well-constructed pitch, it may be possible to sustain usage levels of ten hours per week and sometimes more.
- Sustainable levels are very much influenced by the quality of the pitch that is required and it is essential to recognise that excessive levels of use will both increase maintenance demands and reduce the quality of the playing surface.
- On training pitches and some recreational facilities, it may be possible to use portable goals and mini-pitches at right angles to the normal direction of play to spread the wear across the pitch and to avoid a concentration of wear within the main goal areas.
- In stadium environments, the effects of shade and reduced air circulation can have a major effect on sustainable usage levels. In such environments, the use of growth lights can increase the level of use that can be sustained as well as the quality of the pitch.
- It is important that there is a policy for determining when play can take place under adverse weather conditions. For example, there can be severe damage if a pitch is used when it is badly waterlogged or when it is frozen, particularly after partial thawing which leaves the surface soft but the underlying layer is frozen. If matches are played when pitch conditions are very poor, this can lead to damage which will affect the pitch for the remainder of the playing season.
- When planning the programme of use for a pitch, it is important to make sufficient time available for essential maintenance operations. Some maintenance operations are best spread across two to three days to allow, for example, recovery from aeration and scarification, to give time for fertiliser to be washed in after application and to allow recovery after seeding. There must also be sufficient gaps within the programme of use to allow more intensive maintenance operations to be carried out.

9 Construction and maintenance for the main climate regions

Recommendations for the nine climate areas identified in the map (Figure 1) are given below. It is possible that more than one option is available for some areas, especially if the site is close to the boundary of two or more climate areas or if there are local climate influences such as altitude or proximity to large bodies of water (e.g. large lakes or inland seas) that may moderate the climate.

9.1 Cool, maritime climates

Main characteristics of the climate zone

- high latitude areas that have cool summer temperatures with a short growing period for the grass
- winter temperatures generally modified by proximity to the sea; cold periods, but no continuous periods of snow and frost typical of more continental areas
- variable amount of rainfall, but effective drainage system is needed to remove water due to low evapotranspiration
- only cool-season grasses used



Pitch design

In cool, maritime climates pitch drainage is a major issue, especially as water loss by evapotranspiration is limited during most of the year because of the low temperatures. It is therefore important that there is a suitable drainage system and proper attention is given to surface levels to avoid any water retentive hollows.

There are a number of options available for pitch construction and these depend on the specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

Typically, drains will be installed at 4-6m centres, with the spacing depending on the local soil conditions. There may also be additional sand- or gravel-filled slits that link to the surface of the backfill section of the drain trenches to help water bypass less permeable soils.

For many pitches, especially where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Particularly when any form of slit drainage is used, it is important to allow for appropriate sand dressing as part of the construction work so that a sand-dominated layer builds up at the surface of the pitch to prevent the slits being quickly sealed by the surrounding soil. Further sand application is then needed as part of routine maintenance.

Undersoil heating or pitch protection covers are a major advantage in these colder areas, but for more general-standard facilities, a decision will need to be taken on whether their use is cost-effective. If the budget does not allow for undersoil heating or pitch protection, it must be recognised that the playing season will be shorter and the number of games played will be reduced.

Highest-standard pitches

Higher-quality pitches are designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

In some cases the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

With low temperatures in the spring and possible problems caused by snow and ice at the end of the season, some form of undersoil heating is normally essential, with additional pitch protection covers to help during exceptionally cold weather.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in extreme rainfall. The system can also be used to circulate heated air through the base of the pitch to prevent the surface from freezing and to help the early recovery of grass growth after extreme winter conditions. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth, particularly at the start and end of the playing season. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. Shade assessment, using HemiView analysis for example, will confirm the requirements, running costs and deployment recommendations.

Grass selection

The two main grasses for this climate region will be smooth-stalked meadow-grass (also called Kentucky bluegrass, *Poa pratensis*) and perennial ryegrass (*Lolium perenne*). Smooth-stalked meadow-grass is well adapted to colder climates and will generally survive better over the winter months. Perennial ryegrass establishes more rapidly and is therefore important for renovation and repair work. Generally, both grass species are often used but the proportions in the seed mix may vary at different times of the year.

In wetter areas such as this climate zone, with a lack of high summer temperatures, it is likely that the annual meadow-grass (*Poa annua*) weed species forms a significant part of the grass cover on established pitches. In time, it can give a soft, thatch surface with poor playing characteristics. Although it is rarely possible to eliminate this species, management programmes should aim to minimise the problems associated with this grass type.

For smooth-stalked meadow-grass and perennial ryegrass, significant work has been done by turf breeders to improve the varieties that are available for sports use. Newer varieties or cultivars may have improved wear tolerance, a better colour, increased cleanness of cut and disease resistance, and it is essential to also consider varieties that are better suited to cold, winter conditions. It is important that the most appropriate cultivars are used and information on grass selection should be sought.

Grass establishment

The length of the growing period may have a major influence on the method of grass establishment. Construction work is often delayed until mid-summer because the soil has not dried out adequately in the spring, meaning that construction equipment cannot be used without causing damage to the soil structure. With the lower temperatures in late summer and the autumn, it is difficult to establish the grass by seeding and accordingly, turfing (sodding) is generally used.

Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will usually require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically, turfing will take place in the summer and the pitch will be brought into use the following spring. However, shorter times can be achieved, when necessary, with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Seeding is generally cheaper than turfing and avoids compatibility problems between the soil and the imported turf. However, establishment times for seeded areas are often very slow in this climate area and it may take most of the summer to achieve a grass cover of sufficient density. As the playing season usually finishes in the autumn, it would be the second half of the following summer before the pitch could be brought into use.

Irrigation systems

Although water use is reduced because of the lower temperatures, the long day length in the summer means that grasses are biologically active for most of the day and it is therefore important to consider irrigation requirements for any dry periods in the summer months. Occasional irrigation may be necessary to support grass growth and retain good grass colour. Irrigation may also be important in the preparation of the playing surface, for example to help to avoid excessive hardness.

On more basic pitches, irrigation facilities may not always be available and under these circumstances grass growth will slow down, colour will be lost and the playing surface may become harder. Normally the periods of dry weather are not long enough to cause long-term damage, but the most vulnerable time will be after the initial turfing or after pitch renovation when the new seedlings are establishing. Decisions on irrigation needs must be based on local knowledge of soils and climate and the expected quality of the site.

There are a wide range of options for irrigation depending on the budget available and the required quality. The most likely options are mobile rotary or oscillating sprinklers that can be moved to different parts of the pitch, travelling sprinklers and, in the most basic case, the use of hose pipes, particularly to water vulnerable areas such as goalmouths.

For highest-standard pitches, fully automated pop-up sprinkler systems should normally be used, especially if the rootzone has a high sand content and is likely to dry out. Occasionally, portable sprinklers or travelling sprinklers are used, but this will affect both the uniformity of the water application and have effects on the timing of irrigation before games.

If an irrigation system is installed, it is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth but for general-standard pitches, cutting once or twice weekly is usually sufficient. For higher-grade pitches, cutting three to four times a week may be needed, particularly in the run-up to matches. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for higher-standard pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines must be remarked for each game, but for lower-grade surfaces three to four games or training sessions sometimes take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to four-week intervals and may include both shallow aeration in the top 100mm and less-frequent deeper aeration to 200mm or more (perhaps once to three times per year). On sand-dominated rootzones, the timing of aeration

work is important for avoiding stability problems if excessive aeration has been carried out shortly before games. Care must be taken to avoid damage to undersoil heating pipes if they have been installed.

- **Organic matter control through scarifying:** In colder, moist climates, the rate of breakdown of organic matter will be relatively slow and this can lead to an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations, but care is needed with the frequency and severity of such operations as grass recovery rates are slow at most times of the year.
- **Top dressing with sand:** Sand applications are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and build up a layer of coarser material at the surface to improve drainage and surface firmness. Typically, 30-70 tonnes per pitch are applied annually in one to three applications. On higher level pitches, reinforcement systems are sometimes present and the rate of top dressing may need to be reduced to avoid burying the reinforcement product.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser application is strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, a fertiliser application may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active. On most pitches, it is important that nutrient levels are reduced towards the end of the summer as excessive fertiliser may produce a soft, lush sward that is easily damaged by wear in the early autumn and is more susceptible to disease. However, for stadium pitches where growth lights are used, additional nutrient inputs may be required to sustain the additional growth.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.
- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but in some weather conditions the likelihood of disease can increase considerably. Treatment can either be preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely, or as a reaction to symptoms of disease on the turf.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

Renovation

Renovation requirements will be depend on pitch usage and the amount of damage that occurs. In these colder areas, the growing season and the playing season usually overlap and this does not allow any significant opportunity for renovation of the turf at the end of the season. In general, maintenance operations such as seeding, aeration and sand application have to be fitted in where possible and while there is sufficient growth to ensure full recovery.

9.2 Temperate, maritime climates

Main characteristics of the climate zone

- warm to moderately hot summers, usually with reasonable levels of rainfall (although good irrigation is still important during drier spells).
- regular rainfall and relatively cold winters, but no continuous periods of frost or snow
- winter conditions that make drainage and reduced grass growth important factors affecting the quality of pitches
- only cool-season grasses used



Pitch design

In temperate, maritime climates pitch drainage is a major issue. It is therefore important that there is a suitable drainage system and that proper attention is given to surface levels to avoid any water retentive hollows.

There are a number of options available for pitch construction and these depend on the specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

Typically, drains will be installed at 4-6m centres, with the spacing depending on the local soil conditions. There may also be additional sand- or gravel-filled slits that link to the surface of the backfill section of the drain trenches to help water bypass less permeable soils.

For many pitches, especially where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Particularly when any form of slit drainage is used, it is important to allow for appropriate sand dressing as part of the construction work so that a sand-dominated layer builds up at the surface of the pitch to prevent the slits being quickly sealed by the surrounding soil. Further sand application is then needed as part of routine maintenance.

Highest-standard pitches

High-quality pitches are often designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

The profile may include undersoil heating pipes and in some cases the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in extreme rainfall events and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights that are used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. HemiView analysis will confirm the requirements, running costs and deployment recommendations.

Grass selection

The two main grasses for this climate region will be perennial ryegrass (*Lolium perenne*) and smooth-stalked meadow-grass (also called Kentucky bluegrass, *Poa pratensis*). Perennial ryegrass establishes more rapidly and may be the favoured grass in many parts of the region. However, in areas where summer temperatures are increasing and winters are getting colder, increasing proportions of smooth-stalked meadow-grass will often be used.

In wetter areas such as this climate zone, and without high summer temperatures, it is likely that the weed species annual meadow-grass (*Poa annua*) forms a significant part of the grass cover on established pitches. In time, it can give a soft, thatchy surface with poor playing characteristics. Although it is rarely possible to eliminate this species, good management programmes can reduce the proportion of annual meadow-grass in the sward and can minimise the effects on playing performance.

For perennial ryegrass and smooth-stalked meadow-grass, significant work has been done by turf breeders to improve the varieties that are available for sports use. Newer varieties or cultivars may have improved wear tolerance, a better colour, increased cleanness of cut and disease resistance. It is important that the most appropriate cultivars are used in any region and specialist advice or information on grass selection should be sought.

Grass establishment

Grass can be established either from seed or by turfing (sodding). Seeding is the preferred way to establish grass cover in most cases as it is generally cheaper and avoids problems associated with any soil on the imported turf. However, establishment times for seeding can be between eight and 15 weeks, depending on grass species and weather conditions at the time of seeding.

Where seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will often require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically, five to seven weeks will be required before a pitch can be used, but shorter times can be achieved by using thicker turf rolls (about 40mm) and a very high-quality laying procedure.

Irrigation systems

Although rainfall amounts are relatively high in this region, there will inevitably be dry periods that coincide with hot, summer weather. Effective irrigation is therefore important for supporting grass growth and retaining good grass colour. Irrigation may also be important in the preparation of the playing surface, for example to help to avoid excessive hardness.

On more basic pitches, irrigation facilities may not always be available and under these circumstances grass growth will slow down, colour will be lost and the playing surface may become harder. Normally the periods of dry weather are not long enough to cause long-term damage, but there may be problems in the hotter parts of this region. The most vulnerable time will be after pitch renovation when the new seedlings are establishing. Decisions on irrigation needs must be based on local knowledge of soils and climate and the expected quality of the site.

If an irrigation system is installed, it is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used.

There are a wide range of options for irrigation depending on the budget available and the required quality. These include an automated system with pop-up irrigation heads, mobile sprinklers that can be moved to different parts of the pitch, travelling sprinklers and, in the most basic case, the use hose pipes, particularly to water vulnerable areas such as goalmouths.

Elite-level pitches tend to have an automated irrigation system with pop-up irrigation heads, or sometimes peripheral pop-up heads and mobile sprinklers for the central areas of the pitch. Occasionally, portable rotary or oscillating sprinklers or travelling sprinklers are used, but this will affect both the uniformity of the water application and have effects on the timing of irrigation before games.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth but for basic- and intermediate-grade pitches, cutting one to three times per week is usually appropriate. For elite-grade pitches, daily cutting is often carried out, particularly in the run-up to matches. Normal cutting heights are 25-35mm for general-grade pitches and 25-30mm for elite-level pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines should be remarked for each game, but for lower-grade surfaces three to four games or training sessions sometimes take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to four-week intervals and may include both shallow aeration in the top 100mm and less-frequent deeper aeration to 200mm or more (perhaps once to three times per year). On sand-dominated rootzones, the timing of aeration work is important to avoid stability problems if excessive aeration has been carried out shortly before games. Care must be taken to avoid damage to under-soil heating and irrigation pipes if they have been installed.
- **Organic matter control through scarifying:** When grass growth is good, there can be an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed at times of the year when usage levels are low and growth is good.
- **Top dressing with sand:** Sand applications are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and build up a layer of coarser material at the surface to improve drainage and surface firmness. Typically, 40-80 tonnes per pitch are applied annually in one to three applications. On elite-level pitches, reinforcement systems are sometimes present and the rate of top dressing may need to be reduced to avoid burying the reinforcement product.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser application is strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, a fertiliser application may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active. On most pitches, it is important that nutrient levels are reduced towards the end of the summer as excessive fertiliser may produce a soft, lush sward that is easily damaged by wear in the early autumn and is more susceptible to disease. However, for stadium pitches where grow lights are used, additional nutrient inputs may be required to sustain the additional growth.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.

- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but in some weather conditions the likelihood of disease can increase considerably. Treatment can either be preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely, or as a reaction to symptoms of disease on the turf.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

Renovation

At the end of the playing season, it is essential that a period is set aside to renovate the pitch. This will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, and fertiliser application and seeding to produce a strong, healthy grass cover. A two-to-three month break is normally required to produce a good-quality surface for the start of the next playing season and it is important that all usage is suspended over this period.

9.3 Cool, continental climates

Main characteristics of the climate zone

- warm to moderately hot summers usually with some rainfall (although good irrigation is important for drier spells)
- cold winters with continuous periods of frost and snow
- often poor conditions in the early spring and late autumn – an important factor influencing the quality of pitches
- only cool-season grasses used



Pitch design

In cool, continental climates, pitch drainage is an important issue so that excess water can be removed quickly. It is therefore important that there is a suitable drainage system and proper attention is given to surface levels to avoid any water retentive hollows. In most cases, a slight cross fall or crown to the pitch will be useful to help the removal of excess water.

General-standard pitches

Typically, drains will be installed at 4-6m centres, with the spacing depending on the local soil conditions. There may also be additional sand- or gravel-filled slits that link to the surface of the backfill section of the drain trenches to help water bypass less permeable soils.

For many pitches, especially where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Particularly when any form of slit drainage is used, it is important to allow for appropriate sand dressing as part of the construction work so that a sand-dominated layer builds up at the surface of the pitch to prevent the slits being quickly sealed by the surrounding soil. Further sand application is then needed as part of routine maintenance.

Highest-standard pitches

Higher-quality pitches are normally designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

In some cases the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

An undersoil heating system will normally be installed.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in extreme rainfall. The system can also be used to circulate heated air through the base of the pitch to prevent the surface from freezing and to help the early recovery of grass growth after extreme winter conditions. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights that are used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. Shade assessment, using HemiView analysis for example, will confirm the requirements, running costs and deployment recommendations.

Grass selection

The two main grasses for this climate region will be smooth-stalked meadow-grass (also called Kentucky bluegrass, *Poa pratensis*) and perennial ryegrass (*Lolium perenne*). Smooth-stalked meadow-grass is well adapted to continental-type climates and will generally survive better over the cold winter months. Perennial ryegrass establishes more rapidly and is therefore important for renovation and repair work. Generally, both grass species are often used, but the proportions in the seed mix may vary at different times of the year.

In cooler areas such as this climate zone, it is likely that the annual meadow-grass (*Poa annua*) weed species forms a significant part of the grass cover on established pitches. In time, it can give a soft, thatchy surface with poor playing characteristics. Although it is rarely possible to eliminate this species, management programmes can reduce the proportion of annual meadow-grass in the sward and can minimise the effects on playing performance.

For smooth-stalked meadow-grass and perennial ryegrass, significant work has been done by turf breeders to improve the varieties that are available for sports use. Newer varieties or cultivars may have improved wear tolerance, a better colour, increased cleanness of cut and disease resistance, and it is essential to also consider varieties that are better suited to cold, winter conditions. It is important that the most appropriate cultivars are used and information on cultivar selection should be sought.

Grass establishment

Grass can be established either by seed or by turfing (sodding). Seeding is in most cases the preferred way to establish grass cover as it is generally cheaper and avoids compatibility problems between the soil and the imported turf. However, establishment times for seeding can be between ten to 15 weeks, depending on grass species and weather conditions at the time of seeding.

Where seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will often require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically, five to seven weeks will be required before a pitch can be used, but shorter times can be achieved with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Irrigation systems

Although there are usually reasonable amounts of rainfall in this region, there will inevitably be dry periods that coincide with hot, summer weather. Effective irrigation is therefore important to support grass growth and to retain good grass colour. Irrigation may also be important in the preparation of the playing surface, for example to help to avoid excessive hardness.

On more basic pitches, irrigation facilities may not always be available and under these circumstances grass growth will slow down, colour will be lost and the playing surface may become harder. Often the periods of dry weather are not long enough to cause long-term damage, but there may be problems in the hotter areas of this region. The most vulnerable time will be after pitch renovation when the new seedlings are establishing. Decisions on irrigation needs must be based on local knowledge of soils and climate and the expected quality of the site.

There are a wide range of options for irrigation depending on the budget available and the required quality. These include an automated system with pop-up irrigation heads, mobile rotary or oscillating sprinklers which can be moved to different parts of the pitch, travelling sprinklers and, in the most basic case, the use of hose pipes, particularly to water vulnerable areas such as goalmouths.

Most higher-standard pitches would have an automated irrigation system with pop-up irrigation heads, or sometimes peripheral pop-up heads and mobile sprinklers for the central areas of the pitch. Occasionally, portable sprinklers or travelling sprinklers are used, but this will affect both the uniformity of the water application and have effects on the timing of irrigation before games.

If an irrigation system is installed, it is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth but for general-standard pitches, cutting once to three times per week is usually appropriate. For highest-grade pitches, daily cutting is often carried out, particularly during pitch preparation for matches. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for higher-standard pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines must be remarked for each game, but for lower-grade surfaces three to four games or training sessions often take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development, and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to four-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 250mm or more (perhaps once to three times per year). On sand-dominated rootzones, the timing of the aeration work is important for avoiding stability problems if excessive aeration has been carried out shortly before games. Care must be taken to avoid damage to undersoil heating and irrigation pipes if they have been installed.
- **Organic matter control through scarifying:** When grass growth is good, there can be an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed at times of the year when usage levels are low and growth is good.
- **Top dressing with sand:** Sand applications are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and build up a layer of coarser material to improve drainage and surface firmness. Typically, 40-80 tonnes per pitch are applied annually in one to three applications. On higher-standard pitches, reinforcement systems are sometimes present and the rate of top dressing may need to be reduced to avoid burying the reinforcement product.

- **Fertiliser application.** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser application is strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, a fertiliser application may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active. On most pitches, it is important that nutrient levels are reduced towards the end of the summer as excessive fertiliser may produce a soft, lush sward that is easily damaged by wear in the early autumn and is more susceptible to disease. However, for stadium pitches where growth lights are used, additional nutrient inputs may be required to sustain the additional growth.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.
- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but in some weather conditions the likelihood of disease can increase considerably. Treatment can either be preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely, or as a reaction to symptoms of disease on the turf.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

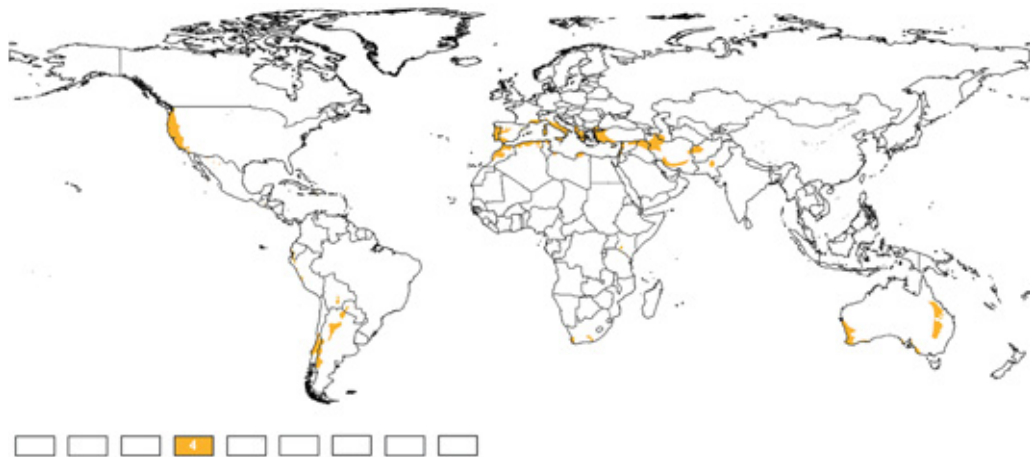
Renovation

At the end of the playing season, it is essential that a period is set aside to renovate the pitch before the onset of the cold winter period. Renovation will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, and seeding. If renovation is carried out too late, it is unlikely that there will be adequate grass development, although in some cases the approach can be to apply the seed in the anticipation that the main germination will take place in the early spring as temperatures warm up. If there is a long playing season and an autumn renovation is not possible, there will need to be shorter periods of overseeding and grass establishment during the main playing season, but the success of this will be strongly influenced by the amount of play taking place.

9.4 Mediterranean type and subtropical/dry summer climates

Main characteristics of the climate zone

- Hot summers usually with little rainfall
- Relatively mild winters usually with more regular rainfall
- Cool-season grasses are mainly used, with warm-season grasses also being appropriate in hotter parts of this region, generally oversown with cool-season grasses in the winter



Pitch design

With drainage being an important factor influencing the quality of pitches in the winter months, it is essential that proper attention is given to surface levels to avoid any water retentive hollows.

In this climate zone, the rainfall in the summer period is usually very limited, but there may be significant winter rainfall which will influence the design that is used. There are a number of options available for pitch construction and these depend on specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

It is important that there is an effective drainage system so that excess water can be removed quickly. Typically, drains will be installed at 5-10m centres, with the spacing depending on the local soil conditions.

On some sites, it may be appropriate to construct a gravel base when new pitches are being built. Although this will inevitably increase the construction costs, it will undoubtedly help in the removal of water from the pitch in wet weather and also help water retention in hot, dry weather. This “suspended water table” effect occurs because as the profile dries out, water is held more tightly in the pores of the soil or sand that forms the upper layer and does not move downwards into the larger pores of the underlying gravel layer. The water thus remains available for uptake by the grass roots and in the long term, this can give substantial savings in terms of water requirements which can offset the higher initial construction costs.

Where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Highest-standard pitches

Higher-quality pitches are normally designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

In some cases, the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in conditions of extreme rainfall and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. Shade assessment, using HemiView analysis for example, will confirm the requirements, running costs and deployment recommendations.

Grass selection

If there is a good-quality irrigation system and summer temperatures are not too high, it may be possible to use cool-season grasses such as perennial ryegrass (*Lolium perenne*), smooth-stalked meadow-grass (also called Kentucky bluegrass, *Poa pratensis*) or tall fescue (*Festuca arundinacea*). These grasses will often be used in mixtures, with the exact proportions depending on the local climate.

In areas with higher summer temperatures or where the availability and quality of the water supply is restricted, it may be more appropriate to use warm-season grasses such as bermudagrass (*Cynodon* species) or seashore paspalum (*Paspalum vaginatum*). These grasses are adapted to hot climates and are therefore at their best in the summer months. However, these grasses can go dormant in the winter (generally when temperatures fall below 10°C) and they lose their green colour, typically becoming pale brown, and growth stops, meaning that there is no recovery from wear. This may be acceptable if it occurs outside the main playing season, but prolonged dormancy during the playing season is likely to result in major damage to the pitch.

A summary of the performance characteristics of a range of grass species that may be considered in Mediterranean type, subtropical/dry summer climates is given below:

	Poorest	Best
High-temperature tolerances	PRG < SSMG < TF < SSP < BG	
Low temperatures and frost	BG < SSP < TF = PRG < SSMG	
Drought stress	PRG < SSMG < TF < SSP = BG	
Low fertility	BG < SSMG < PRG < TF < SSP	
Wear	SSMG < TF = PRG = SSP < BG	
Grass establishment	BG = SSP < SSMG < TF < PRG	
Salinity	SSMG < PR < TF < BG < SSP	
Tolerance of close mowing	TF < SSMG < SSP = PRG < BG	

PRG = Perennial ryegrass

BG = Bermudagrass

SSMG = Smooth-stalked meadow-grass

SSP = Seashore paspalum

TF = Tall fescue

If warm-season grasses are used but are likely to go dormant, the normal approach would be to overseed the grass with a cool-season species (usually perennial ryegrass) in the autumn to retain the required colour and recovery. This is often a successful strategy, provided that the work is carried out with the correct timing and preparation and an appropriate seeding rate is used. However, it is important to recognise that pitch usage will be restricted after overseeding to allow proper establishment of the newly seeded grass and that in the spring, there can be a patchy appearance to the sward as the cool-season grasses are lost before the warm-season grass becomes fully active and dominant (selective herbicides are often used to help this transition period).

The selection of grasses in this type of climate is often a very significant factor influencing the quality of the pitch. Examination of other pitches in the area to see which grasses perform most effectively is very helpful, but additional information will also be required on the most appropriate varieties within each grass species.

In larger stadiums with significant shading, it is usually safer to use cool-season grasses as the warm-season grasses will struggle when light levels are poor.

Grass establishment

Grass can be established in a number of ways. The most common approach is either from seed or by turfing (sodding), but for some warm-season grasses sprigging is used, with the grass being developed from shredded pieces of the grass tissue which are pressed into the surface and then develop vegetatively to give a full grass cover.

Seeding and sprigging are in most cases the preferred ways to establish grass cover as they are generally cheaper and avoid compatibility problems between the soil and the imported turf. However, establishment times for seeding and sprigging can be between eight and 20 weeks, depending on the grass species and weather conditions at the time of seeding/sprigging.

Where seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will often require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically, five to seven weeks will be required before a pitch can be used, but shorter times can be achieved with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Irrigation systems

In hot, summer weather, regular irrigation is essential to support grass growth and retain a good grass colour. In addition, even during cooler times of the year, irrigation may be important in the preparation of a good-quality surface, for example to help to avoid excessive hardness.

During very hot summer weather, irrigation requirements may reach up to about 7mm per day (56 cubic metres for an 8000m² pitch). In case of water supply failure, it is advisable to store this volume of water in tanks on site to give a safety margin of 24 hours until the water supply can be restored.

It is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used. The quality of water is very influential and water containing a high content of dissolved salts can have a major effect on turf quality.

The design of the irrigation system is vital and it is important that water is applied uniformly. In the hot summers of these regions, a good-quality, fully automated pop-up irrigation system is the preferred option. Generally, the minimum requirement is about 20 pop-up heads, but the better designs tend to have 24-35 heads with a full overlap between adjacent sprinklers.

Alternative irrigation options include perimeter pop-up sprinklers with mobile sprinklers in the centre of the pitch, mobile rotary or oscillating sprinklers, travelling sprinklers and irrigation cannons. However, this results in less uniform coverage and there is greater reliance on ground staff to carry out the irrigation.

An automated pop-up system also has major advantages in that water can be applied at night using a timer system, thus reducing evaporation losses.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth, but for general pitches cutting once to three times per week is usually appropriate. For highest-grade pitches, daily cutting is often carried out, especially during preparation for matches. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for higher-standard pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines must be remarked for each game, but for lower-grade surfaces three to four games or training sessions often take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to six-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 250mm or more (perhaps once to three times per year). On sand-dominated rootzones, the timing of aeration work is important for avoiding stability problems if excessive aeration has been carried out shortly before games. Care must be taken to avoid damage to any irrigation pipes.
- **Organic matter control through scarifying:** When grass growth is good, there can be an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed at times of the year when usage levels are low and growth is good.
- **Top dressing with sand:** Sand applications (sometimes incorporating soil or organic and inorganic amendment materials) are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and to improve surface firmness. Typically, 30-70 tonnes per pitch are applied annually in one to three applications. On higher-grade pitches, reinforcement systems are sometimes installed and the rate of top dressing may need to be reduced to avoid burying the reinforcement product.

- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser application is strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, a fertiliser application may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active. On most pitches, it is important that nutrient levels are reduced in the autumn as excessive fertiliser may produce a soft, lush sward that is easily damaged by wear and is more susceptible to disease. However, for stadium pitches where growth lights are used, additional nutrient inputs may be required to sustain the additional growth.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.
- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but in some weather conditions the likelihood of disease can increase considerably. Treatment can either be preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely, or as a reaction to symptoms of disease on the turf.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

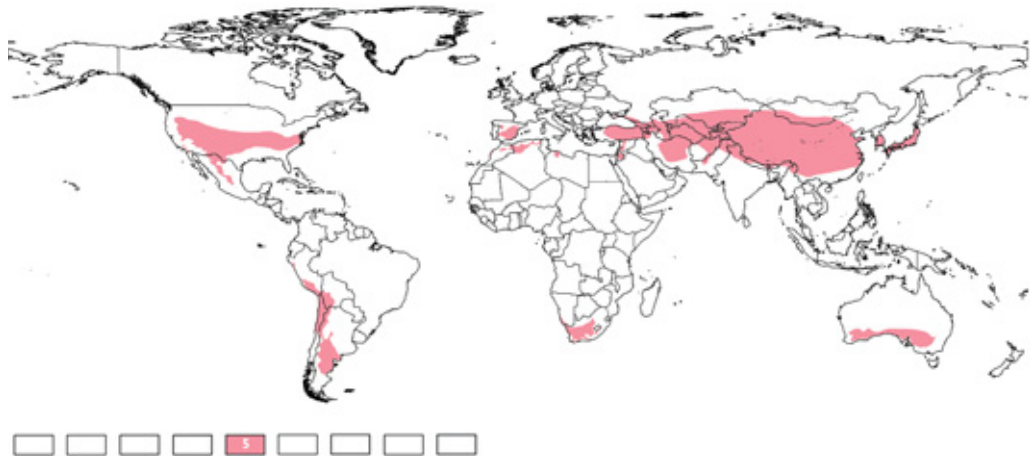
Renovation

At the end of the playing season it is essential that a period is set aside to renovate the pitch. This will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, fertiliser application, and seeding to produce a strong, healthy grass cover. With the low summer rainfall and high temperatures, it is particularly important that irrigation is carried out to a good standard. Normally a two-to-three-month break is required to produce a good-quality surface for the start of the next playing season, and it is important that all usage is suspended over this period.

9.5 Continental, transition zone climates

Main characteristics of the climate zone

- hot summers
- relatively cold winters with the possibility of frost and snow
- hot summer conditions result in significant stress for cool-season grasses
- warm-season grasses are likely to become dormant in the winter months
- both warm-season and cool-season grasses are generally used, with the cool-season grasses being sown into the warm-season grasses before the start of the winter period
- continental climate: rainfall may be limited during parts of the year, hence the requirement for an effective irrigation system



Pitch design

There are a number of options for pitch construction and these will depend on specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

In many of these areas, there can be significant winter rainfall and it is important that there is an effective drainage system so that excess water can be removed quickly. Typically, drains will be installed at 5-10m centres, with the spacing depending on rainfall intensity and the local soil conditions.

On some sites, it may be appropriate to construct a gravel base when new pitches are being built. Although this will inevitably increase the construction costs, it will undoubtedly help in the removal of water from the pitch in wet weather and will also help water retention in hot, dry weather. This “suspended water table” effect occurs because as the profile dries out, water is held more tightly in the pores of the soil or sand that forms the upper layer and does not move downwards into the larger pores of the underlying gravel layer. The water then remains available for uptake by the grass roots and in the long term, this can give substantial savings in terms of water requirements which can offset the higher initial construction costs.

For many pitches, especially where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction, which can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Highest-standard pitches

Higher-quality pitches are normally designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

The profile may include undersoil heating pipes, and in some cases the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in conditions of extreme rainfall and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. Shade assessment, using HemiView analysis for example, will confirm the requirements, running costs and deployment recommendations.

Grass selection

If there is a good-quality irrigation system and summer temperatures are not too high, it might be possible to use cool-season grasses such as perennial ryegrass (*Lolium perenne*), smooth-stalked meadow-grass (also called Kentucky bluegrass, *Poa pratensis*) or tall fescue (*Festuca arundinacea*). However, these grasses could be subject to high levels of stress in the summer, which would increase the intensity of maintenance required and limit the use of the pitches at that time of the year.

In areas with high summer temperatures and where the availability and quality of the water supply is restricted, it is usually more appropriate to use warm-season grasses such as bermudagrass (*Cynodon* species) or seashore paspalum (*Paspalum vaginatum*). These grasses are adapted to hot climates and are therefore at their best in the summer months. In the transition zone, however, winter temperatures are low enough to make these grasses go dormant in the winter (generally when average temperatures fall below 10°C or after the first frost). They lose their green colour, typically becoming pale brown, and growth stops meaning that there is no recovery from wear. This may be acceptable if it occurs outside the main playing season, but prolonged dormancy during the playing season is likely to result in major damage to the pitch.

If the warm-season grasses are likely to go dormant, the normal approach would be to overseed the grass with a cool-season species (usually perennial ryegrass, *Lolium perenne*) in the autumn to retain the required colour and recovery. This is often a successful strategy, provided that the work is carried out with the correct timing and preparation and an appropriate seeding rate is used. However, it is important to recognise that pitch usage will be restricted after overseeding to allow proper establishment of the newly seeded grass and that in the spring there can be a patchy appearance to the sward as the cool-season grasses are lost before the warm-season grass becomes fully active and dominant (selective herbicides are often used to help this transition period).

A summary of the performance characteristics of a range of grass species that may be considered in transition zone climates is given below:

	Poorest	Best
High temperature tolerances	PRG < SSMG < TF < SSP < BG	
Low temperatures and frost	BG < SSP < TF = PRG < SSMG	
Drought stress	PRG < SSMG < TF < SSP = BG	
Low fertility	BG < SSMG < PRG < TF < SSP	
Wear	SSMG < TF = PRG = SSP < BG	
Grass establishment	BG = SSP < SSMG < TF < PRG	
Salinity	SSMG < PR < TF < BG < SSP	
Tolerance of close mowing	TF < SSMG < SSP = PRG < BG	

PRG = Perennial ryegrass

BG = Bermudagrass

SSMG = Smooth-stalked meadow-grass

SSP = Seashore paspalum

TF = Tall fescue

The selection of grasses in this type of climate is often a very significant factor influencing the quality of the pitch. Examination of other pitches in the area to see which grasses perform most effectively is very helpful, but additional information will also be required on the most appropriate varieties within each grass species.

Grass establishment

Normally the warm-season grass will be established first and there are a number of approaches. Seed can be used for some varieties, but many varieties are sterile and have to be established by either sprigging or turving. For sprigging, the grass is developed from shredded pieces of the grass tissue which are pressed into the surface and then develop vegetatively by lateral spreading to give a full grass cover.

Where seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will often require hollow tine aeration after laying to help drainage and root development. The timing of the overseeding with cool-season grasses is very important due to the fact that if the warm-season grass is growing strongly, it will outcompete the newly sown grass. The existing sward would normally be heavily scarified to open it up before overseeding, and it may be necessary to use an approved growth suppressant on the warm-season grass before the cool-season grass is sown to slow down growth and thus create favourable conditions for the cool-season grass.

Irrigation systems

In hot, summer weather, regular irrigation is essential to support grass growth and retain a good grass colour. In addition, even during cooler times of the year, irrigation may be important in the preparation of a good-quality surface, for example to help to avoid excessive hardness.

During very hot summer weather, irrigation requirements may reach up to about 8mm per day (64 cubic metres for an 8000m² pitch). In case of water supply failure, it is advisable to store this volume of water in tanks on site to give a safety margin of 24 hours until the water supply can be restored.

It is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used. The quality of water is very influential and water containing a high content of dissolved salts can have major effects on turf quality.

The design of the irrigation system is vital and it is important for water to be applied uniformly. In the hot summers of these regions, a good-quality, fully automated pop-up irrigation system is the preferred option. Generally, the minimum requirement is about 20 pop-up heads, but the better designs tend to have 24-35 heads with a full overlap between adjacent sprinklers.

Alternative irrigation options include perimeter pop-up sprinklers with mobile sprinklers in the centre of the pitch, mobile rotary or oscillating sprinklers and irrigation guns. However, coverage is less uniform and there is greater reliance on ground staff to carry out the irrigation.

An automated pop-up system also has major advantages in that water can be applied at night using a timer system, thus reducing evaporation losses.

In some transition zone areas, there can be significant issues with water quality, which lead to problems of salinity. It is important that water quality is monitored at the outset of the project and if salinity is an issue, then construction and management procedures must be modified to take into account the build-up of salts in the soil.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth but for general level pitches, cutting once to three times per week is usually appropriate. For highest-quality pitches, daily cutting is often carried out, particularly in the run-up to matches. Normal cutting heights are 25-35mm for general level pitches and 25-30mm for highest-standard pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines should be remarked for each game, but for lower-grade surfaces three to four games or training sessions often take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to six-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 250mm or more (perhaps once to three times per year). During hot, dry conditions, it may be necessary to delay any aeration work as spiking may affect grass recovery.
- **Organic matter control through scarifying:** When grass growth is good, there can be an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed at times of the year when usage levels are low and growth is good. As with aeration work, it may be necessary to delay operations in very hot, dry weather.
- **Top dressing with sand:** Sand applications (sometimes incorporating soil or organic and inorganic amendment materials) are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and to improve surface firmness. Typically, 30-70 tonnes per pitch are applied annually in one to three applications. On high-standard pitches, reinforcement systems are sometimes present and the rate of top dressing may need to be reduced to avoid burying the reinforcement product.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser application is strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, a fertiliser application may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active. On most pitches, it is important that nutrient levels are reduced in the autumn as excessive fertiliser may produce a soft, lush sward that is easily damaged by wear and is more susceptible to disease. However, for stadium pitches where growth lights are used, additional nutrient inputs may be required to sustain the additional growth.

- If salinity is an issue at the site, it may be necessary to adapt the irrigation programme to include periods of over-watering to wash out any excess salts. It may also be appropriate to apply gypsum to help reduce the effects of salt on the soil structure.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.
- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but in some weather conditions the likelihood of disease can increase considerably. Treatment can either be preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely, or as a reaction to symptoms of disease on the turf.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

Renovation

At the end of the playing season, it is essential that a period is set aside to renovate the pitch. This will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, fertiliser application, and seeding to produce a strong, healthy grass cover. There are often high temperatures at the time of renovation, so a good-quality irrigation programme is needed. Normally, a two-to-three-month break is required to produce a good-quality surface for the start of the next playing season and it is important that all usage is suspended over this period.

9.6 Subtropical zone climates

Main characteristics of the climate zone

- hot summers
- mild or warm winters with a very low risk of frost
- often relatively high annual rainfall, but there can be some drier periods, making an effective irrigation system essential
- warm-season grasses are mainly used, but in cooler parts of the region (e.g. because of altitude or shade within stadiums), it may be necessary to overseed for the winter with cool-season grasses



Pitch design

There are a number of options available for pitch construction and these will depend on the specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

Many subtropical areas can have significant rainfall and it is important that there is an effective drainage system so that excess water can be removed quickly. Typically, drains will be installed at 4-5m centres, with the spacing depending on the local soil conditions.

On some sites, it may be appropriate to construct a gravel base when new pitches are being built. Although this will inevitably increase the construction costs, it will undoubtedly help in the removal of water from the pitch in wet weather and will also help water retention in hot, dry weather. This “suspended water table” effect occurs because as the profile dries out, water is held more tightly in the pores of the soil or sand that forms the upper layer and does not move downwards into the larger pores of the underlying gravel layer. The water then remains available for uptake by the grass roots and in the long term, this can give substantial savings in terms of water requirements which can offset the higher initial construction costs.

For many pitches, especially where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Highest-standard pitches

Higher-quality pitches are designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

In some cases, the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in conditions of extreme rainfall and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. HemiView analysis will confirm the requirements, running costs and deployment recommendations.

Grass selection

For the subtropical regions, warm-season grasses should normally be used, with the main options including bermudagrass (*Cynodon* species), zoysiagrass (*Zoysia japonica*) and possibly seashore paspalum (*Paspalum vaginatum*).

There may be some exceptions, particularly in mountainous areas where temperatures are lower and there may be some risk of frost. Particular care is needed in heavily shaded stadium sites, and in some cases cool-season grasses may be a better option, even though warm-season grasses perform well on more open sites in the area.

The selection of grasses in this type of climate is often a very significant factor influencing the quality of the pitch. Examination of other pitches in the area to see which grasses perform most effectively is very helpful, but additional information will also be required on the most appropriate varieties within each grass species.

Grass establishment

A number of approaches can be used and these will depend on the grass type that is selected. Seed can be used for some varieties, but many varieties are sterile and have to be established by either sprigging or turfing. For sprigging, the grass is developed from shredded pieces of the grass tissue which are pressed into the surface and then develop vegetatively by lateral spreading to give a full grass cover.

Seeding and sprigging are in most cases the preferred ways to establish grass cover as they are generally cheaper and avoid compatibility problems between the soil and the imported turf. However, establishment times for seeding and sprigging can be between eight and 20 weeks, depending on the grass species and weather conditions at the time of seeding/sprigging.

Where sprigging or seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will usually require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically five to seven weeks will be required before a pitch can be used, but shorter times can be achieved with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Irrigation systems

Although rainfall is often high, a good irrigation system is essential during drier periods to support grass growth and retain a good grass colour and for the preparation of a good-quality surface, for example to help to avoid excessive hardness.

In dry weather, irrigation requirements may reach up to about 8mm per day (64 cubic metres for an 8000m² pitch). In case of water supply failure, it is advisable to store this volume of water on site in tanks to give a safety margin of 24 hours until the water supply can be restored.

It is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used.

Ideally, pitches should have an automated irrigation system with pop-up irrigation heads, or sometimes peripheral pop-up heads and mobile sprinklers for the central areas of the pitch. Occasionally, portable rotary or oscillating sprinklers and travelling sprinklers are used, but this will affect both the uniformity of the watering and the timing of irrigation before games.

The design of the irrigation system is vital and it is important that water is applied uniformly. Therefore, a good-quality, fully automated pop-up irrigation system is the preferred option. Usually, the minimum requirement is about 20 pop-up heads, but the better designs tend to have 24-35 heads, with a full overlap between adjacent sprinklers.

An automated pop-up system also has major advantages in that water can be applied at night using a timer system, thus reducing evaporation losses.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth but for general-standard pitches, cutting twice per week is usually appropriate, while higher standard pitches may be cut three or four times per week. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for high-standard pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines should be remarked for each game, but for lower-grade surfaces three to four games or training sessions sometimes take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to six-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 250mm or more (perhaps once to three times per year). Hollow coring, in conjunction with sand dressing, is often used as part of the programme to control the build-up of organic matter.
- **Organic matter control through scarifying:** When grass growth is good, there can be an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed at times of the year when usage levels are low and growth is good.
- **Top dressing with sand:** Sand applications (sometimes incorporating soil or organic and inorganic amendment materials) are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and to improve surface firmness. Typically, 40-80 tonnes per pitch are applied annually in two to four applications.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser application is strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, a fertiliser application may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population, but because of the high temperatures and moist climate, weeds will spread rapidly if not treated effectively. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.

- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but because of the high temperatures and regular rainfall, disease risks are high in this region. Treatments are usually preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely. However, if disease is evident, rapid reactions to symptoms of disease on the turf are important.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

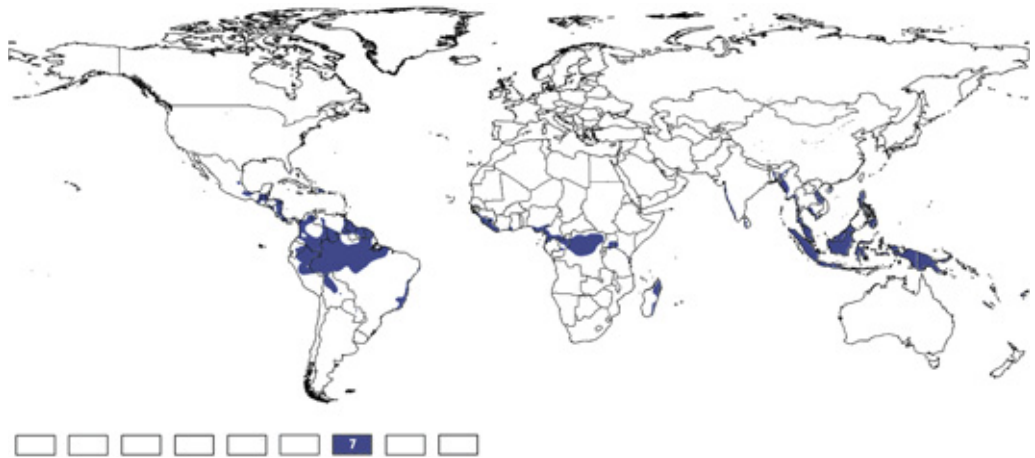
Renovation

At the end of the playing season, it is essential that a period is set aside to renovate the pitch. This will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, fertiliser application, and localised sprigging or returving to produce a strong, healthy grass cover. Normally, a six- to ten-week break is required to produce a good-quality surface for the start of the next playing season and it is important that all usage is suspended over this period.

9.7 Tropical/high-rainfall climates

Main characteristics of the climate zone

- tropical climate requiring the use of warm-season grasses
- regular and often intense and prolonged rainfall
- there may be occasional drier spells despite the high annual rainfall, and given the high temperatures, an effective irrigation system is generally essential
- warm-season grasses normally used



Pitch design

There are a number of options available for pitch construction and these will depend on the specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

Areas such as these can have regular and often intense rainfall, so it is important that there is an effective drainage system so that excess water can be removed quickly. Typically, drains will be installed at 4-5m centres, with the spacing depending on the local soil conditions. There may also be additional sand- or gravel-filled slits that link to the surface of the backfill section of the drain trenches to help water bypass less permeable soils.

On some sites, it may be appropriate to construct a gravel base when new pitches are being built. Although this will inevitably increase the construction costs, it will undoubtedly help in the removal of water from the pitch in wet weather and will also help water retention in hot, dry weather. This “suspended water table” effect occurs because as the profile dries out, water is held more tightly in the pores of the soil or sand that forms the upper layer and does not move downwards into the larger pores of the underlying gravel layer. The water then remains available for uptake by the grass roots and in the long term, this can give substantial savings in terms of water requirements, which can offset the higher initial construction costs.

For many pitches, where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. It may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Highest-standard pitches

Higher-quality pitches are designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers. In some cases, the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in conditions of extreme rainfall and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. Shade assessment, using HemiView analysis for example, will confirm the requirements, running costs and deployment recommendations.

Grass selection

Grass selection will be influenced by the climate conditions of the site, the nature of the construction that is used, the required quality of the pitch, maintenance resources and the amount and quality of the irrigation water that is available.

Warm-season grasses should be used and the main options are bermudagrass (*Cynodon* species), zoysia species (*Zoysia japonica* or sometimes *Zoysia matrella*) and possibly seashore paspalum (*Paspalum vaginatum*).

The selection of grasses in this type of climate is often a very significant factor influencing the quality of the pitch. Examination of other pitches in the area to see which grasses perform most effectively is very helpful, but additional information will also be required on the most appropriate varieties within each grass species.

It should be noted that in heavily shaded stadiums, grass growth may be very difficult with warm-season grasses. Therefore, very careful consideration should be given to the best grass selection in these circumstances.

Grass establishment

A number of approaches can be used and these will depend on the grass type that is selected. Seed can be used for some varieties, but many varieties are sterile and have to be established by either sprigging or turfing (sodding). For sprigging, the grass is developed from shredded pieces of the grass tissue which are pressed into the surface and then develop vegetatively by lateral spreading to give a full grass cover.

Sprigging and seeding are in most cases the preferred ways to establish grass cover as they are generally cheaper and avoid compatibility problems between the soil and the imported turf. However, establishment times for sprigging and seeding can be between eight and 20 weeks, depending on the grass species and weather conditions at the time of seeding/sprigging.

Where sprigging or seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will usually require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically, five to seven weeks will be required before a pitch can be used, but shorter times can be achieved with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Irrigation systems

Although annual rainfall is high in these regions, a good irrigation system is often required if there are occasional dry periods. In particular, irrigation may be needed to support grass growth and retain a good grass colour, but watering may also be important for the preparation of a good-quality surface, for example to help to avoid excessive hardness.

In dry weather, irrigation requirements may reach up to about 8mm per day (64 cubic metres for an 8000m² pitch). In case of water supply failure, it is advisable to store this volume of water on site in tanks to give a safety margin of 24 hours until the water supply can be restored.

It is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used.

If there is particularly regular rainfall, it may be possible to rely on a relatively simple irrigation system for watering during short dry spells. More basic irrigation options include portable rotary or oscillating sprinklers, travelling sprinklers and irrigation guns. However, coverage is less uniform and there is greater reliance on ground staff to set up and move equipment during irrigation.

For higher-standard pitches or where rainfall is less reliable, a fully automated pop-up irrigation system or peripheral pop-up heads and mobile sprinklers for the central areas of the pitch is often the better option.

An automated pop-up system also has major advantages in that water can be applied at night using a timer system, thus reducing evaporation losses.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth but for general-standard pitches, cutting twice per week is usually appropriate, while higher-standard pitches may be cut three to four times per week. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for highest-grade pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines must be remarked for each game, but for lower-grade surfaces three to four games or training sessions sometimes take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to six-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 250mm or more (perhaps once to three times per year). Hollow coring, in conjunction with sand dressing, is often used as part of the programme to control the build-up of organic matter.
- **Organic matter control through scarifying:** There is usually strong grass growth for most of the year and therefore, there can be an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll, and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed.
- **Top dressing with sand:** Sand applications (sometimes incorporating soil or organic and inorganic amendment materials) are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and to improve surface firmness. Typically, 50-80 tonnes per pitch are applied annually in two to four applications.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser applications are strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, fertiliser may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active.
- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population, but because of the high temperatures and moist climate, weeds will spread rapidly if not treated effectively. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.

- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but because of the high temperatures and regular rainfall, disease risks are high in this region. Treatments are usually preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely. However, if disease is evident, rapid reactions to symptoms of disease on the turf are important.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

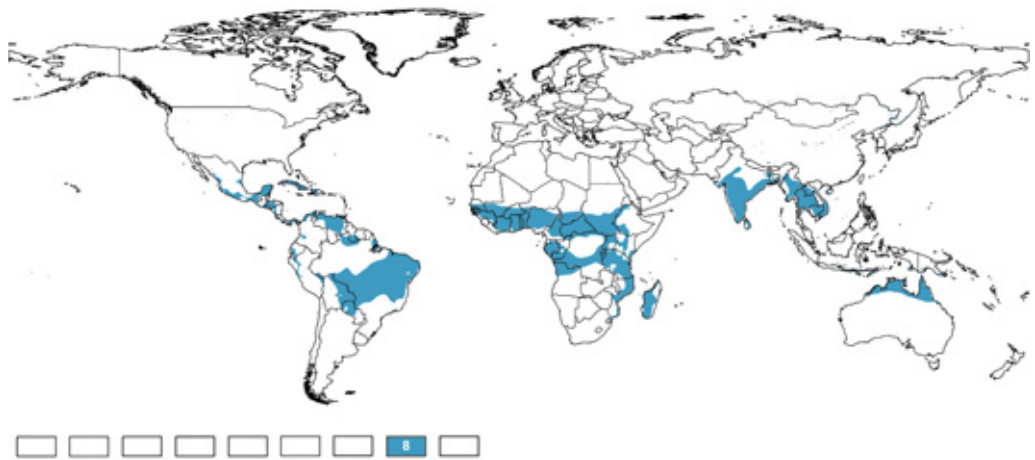
Renovation

At the end of the playing season, it is essential that a period is set aside to renovate the pitch. This will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, fertiliser application, and localised seeding, sprigging or returving to produce a strong, healthy grass cover. Normally a six- to ten-week break is required to produce a good-quality surface for the start of the next playing season and it is important that all usage is suspended over this period.

9.8 Tropical climates with seasonal rainfall

Main characteristics of the climate zone

- high temperatures throughout the year, meaning that warm-season grasses are required
- rainfall that varies seasonally, with high and often intense rainfall during part of the year, but prolonged dry periods at other times
- the dry periods with high temperatures mean that a good-quality irrigation system is important
- warm-season grasses normally used



Pitch design

There are a number of options available for pitch construction and these will depend on the specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

Areas with this type of climate can have regular and often intense rainfall, so it is important to have an effective drainage system to ensure that excess water can be removed quickly. Typically, drains will be installed at 4-5m centres, with the spacing depending on the local soil conditions. There may also be additional sand- or gravel-filled slits that link to the surface of the backfill section of the drain trenches to help water bypass less permeable soils.

On some sites, it may be appropriate to construct a gravel base when new pitches are being built. Although this will inevitably increase the construction costs, it will undoubtedly help in the removal of water from the pitch in wet weather and will also help water retention in hot, dry weather. This “suspended water table” effect occurs because as the profile dries out, water is held more tightly in the pores of the soil or sand that forms the upper layer and does not move downwards into the larger pores of the underlying gravel layer. The water then remains available for uptake by the grass roots and in the long term, this can give substantial savings in terms of water requirements, which can offset the higher initial construction costs.

For many pitches, where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development, and the firmness and stability of the surface for play. For pitches of a reasonable standard, it may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Highest-standard pitches

Higher-quality pitches are designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers.

In some cases, the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in conditions of extreme rainfall and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. HemiView analysis will confirm the requirements, running costs and deployment recommendations.

Grass selection

Grass selection will be influenced by the climate conditions of the site, the nature of the construction that is used, the required quality of the pitch, maintenance resources and the amount and quality of the irrigation water that is available.

Warm-season grasses should be used, with the main options being bermudagrass (*Cynodon* species), zoysia species (*Zoysia japonica* or sometimes *Zoysia matrella*) and possibly seashore paspalum (*Paspalum vaginatum*).

The selection of grasses in this type of climate is often a very significant factor influencing the quality of the pitch. Examination of other pitches in the area to see which grasses perform most effectively is very helpful, but additional information will also be required on the most appropriate varieties within each grass species.

It should be noted that in heavily shaded stadiums, grass growth may be very difficult with warm-season grasses. Very careful consideration should therefore be given to the best grass selection in these circumstances.

Grass establishment

A number of approaches can be used and these will depend on the grass type that is selected. Seed can be used for some varieties, but many varieties are sterile and have to be established by either sprigging or turfing (sodding). For sprigging, the grass is developed from shredded pieces of the grass tissue which are pressed into the surface and then develop vegetatively by lateral spreading to give a full grass cover.

Sprigging and seeding are in most cases the preferred ways to establish grass cover as they are generally cheaper and avoid compatibility problems between the soil and the imported turf. However, establishment times for sprigging or seeding can be between eight and 20 weeks, depending on grass species and weather conditions at the time of sprigging/seeding.

Where sprigging or seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will usually require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically, five to seven weeks will be required before a pitch can be used, but shorter times can be achieved with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Irrigation systems

Although annual rainfall is high in these regions, a good irrigation system is essential during dry periods to support grass growth and retain a good grass colour. Irrigation may also be important for the preparation of a good-quality surface, for example to help to avoid excessive hardness. More basic irrigation systems include portable rotary or oscillating sprinklers, travelling sprinklers and irrigation guns. However, coverage is less uniform and there is greater reliance on ground staff to carry out the irrigation.

Most larger stadiums would have an automated irrigation system with pop-up irrigation heads, or sometimes peripheral pop-up heads and mobile sprinklers for the central areas of the pitch. An automated pop-up system also has major advantages in that water can be applied at night using a timer system, thus reducing evaporation losses.

The design of the irrigation system is vital and it is important that water is applied uniformly. A good-quality, fully automated pop-up irrigation system is therefore the preferred option. Generally, the minimum requirement is about 20 pop-up heads, but the better designs tend to have 24-35 heads, with a full overlap between adjacent sprinklers.

In dry weather, irrigation requirements may reach up to 8-10mm per day (64-80 cubic metres for an 8000m² pitch). In case of water supply failure, it is advisable to store this volume of water on site in tanks to give a safety margin of 24 hours until the water supply can be restored.

If an irrigation system is installed, it is important that there is a reliable supply of water. This is usually a borehole feed, but sometimes the mains water supply can also be used.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth, but for general-standard pitches cutting twice per week is usually appropriate, while higher-standard pitches may be cut three to four times per week. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for highest-grade pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines must be remarked for each game, but for lower-grade surfaces three to four games or training sessions sometimes take place before the lines are remarked.
- **Aeration/spiking:** Aeration is used to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development, and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at two- to six-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 200mm or more (perhaps once to three times per year). Hollow coring, in conjunction with sand dressing, is often used as part of the programme to control the build-up of organic matter.
- **Organic matter control through scarifying:** There is usually strong grass growth for most of the year, which can possibly result in an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch, but monthly operations may be needed.
- **Top dressing with sand:** Sand applications (sometimes incorporating soil or organic and inorganic amendment materials) are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and to improve surface firmness. Typically, 40-80 tonnes per pitch are applied annually in two to four applications.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser applications are strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, fertiliser may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active.

- **Weed control:** Weed control will largely depend on the local site conditions and the nature of the weed population, but because of the high temperatures and moist climate, weeds will spread rapidly if not treated effectively. Some weed types can easily be removed by hand weeding, but selective herbicides are generally more effective for most weed species.
- **Disease control:** There are many diseases that can affect the quality of the turf, but the most common are fungal diseases. The risk of disease will be influenced by the quality of management, with poorly growing turf being much more susceptible to disease problems. A good quality management programme can help reduce the risk of disease, but because of the high temperatures and wet periods in this region, disease risks are high. Treatments are usually preventative, with for example a fungicide being applied at times of the year when outbreaks of a specific disease are likely. However, if disease is evident, rapid reaction to symptoms of disease on the turf is important.
- **Pest control:** Turf pests include insects (often the larval forms), earthworms and sometimes birds or mammals that cause damage usually when they are digging for insects or earthworms. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

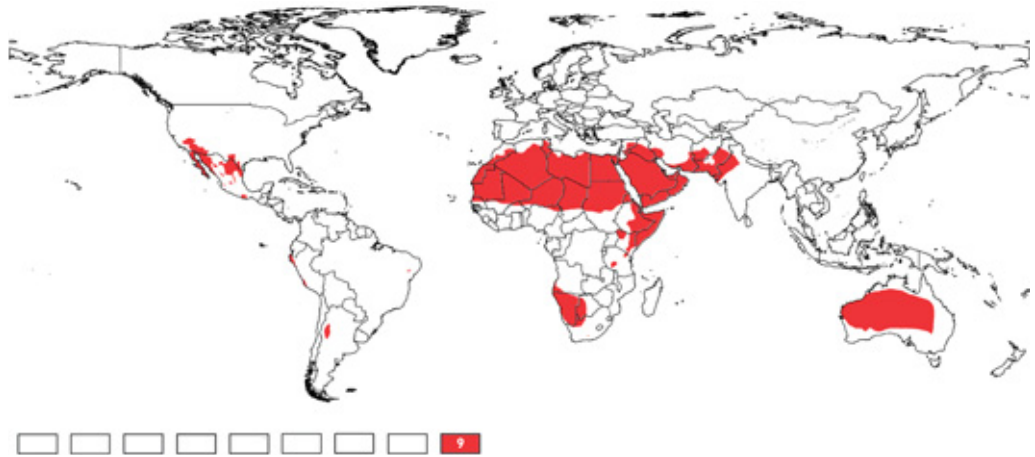
Renovation

At the end of the playing season, it is essential that a period is set aside to renovate the pitch. This will typically include aeration to relieve compaction, scarification, sand dressing to improve levels and dilute organic matter and accumulated finer materials in the surface layer, fertiliser application, and localised seeding, sprigging or returfing to produce a strong, healthy grass cover. Normally a six-to-ten week break is required to produce a good-quality surface for the start of the next playing season and it is important that all usage is suspended over this period.

9.9 Hot, semi-arid and arid climates

Main characteristics of the climate zone

- hot conditions that dictate the use of warm-season grasses
- the combination of high temperatures and low levels of rainfall mean that a good-quality irrigation system is essential
- warm-season grasses normally used



Pitch design

There are a number of options available for pitch construction and these will depend on the specific site conditions, the risk of cancellation of fixtures and the budget available.

General-standard pitches

Even though the areas concerned generally have low rainfall, it is nevertheless sensible to have an effective drainage system in case of occasional heavy rainfall. More importantly, on sites that have potential problems with salinity, a good drainage system is essential so that salts can be flushed from the pitch at intervals by heavy watering. Typically, drains will be installed at 5-10m centres, with the spacing depending on the local soil conditions and the need for the flushing of salts.

On some sites it may be appropriate to construct a gravel base when new pitches are being built. Although this will inevitably increase the construction costs, it will undoubtedly help in the removal of water from the pitch in wet weather and will also help water retention in hot, dry weather. This "suspended water table" effect occurs because as the profile dries out, water is held more tightly in the pores of the soil or sand that forms the upper layer and does not move downwards into the larger pores of the underlying gravel layer. The water then remains available for uptake by the grass roots and in the long term, this can give substantial savings in terms of water requirements, which can offset the higher initial construction costs. The use of a gravel drainage carpet is also a good strategy for pitches where the irrigation water is of poor quality as this boosts the uniformity of flushing to remove excess salts.

For many pitches, where budgets are restricted, it may be necessary to use the existing topsoil of the site as the growing medium. However, any soils with significant amounts of clay or silt will be susceptible to the effects of compaction and this can influence factors such as drainage, root development and the firmness and stability of the surface for play. Clay-rich soils are particularly susceptible to structural breakdown if there are salinity issues on the site. On a similar basis, some very sandy soils may have problems with poor water retention and the addition of a suitable water-retentive amendment may be an advantage. For pitches of a reasonable standard, it may be necessary to include a purpose-made rootzone, for example a mix of sand with soil or organic amendment.

Highest-standard pitches

Pitches are usually designed to have a number of engineered layers over an appropriate drainage system. Typically, there will be a gravel base consisting of one or more layers and sand-dominated upper layers. In some cases, the upper layer may be reinforced with a range of materials (for example, plastic fibres that are mixed or punched into the rootzone) to improve surface strength, especially if grass cover is lost.

Depending on weather conditions and the stadium environment, a suction and air circulation system may also be used in the design. Such systems may be of benefit for the removal of surface water in conditions of extreme rainfall and may help in air exchange and temperature regulation. The installation is of a specialist nature.

In large stadiums where there are high levels of shading, it may be necessary to use a system of supplementary lighting to improve the quality of grass growth. It is essential that the lights used operate within the photosynthetically active range and that the coverage and deployment of the light units are carefully considered. Shade assessment, using HemiView analysis for example, will confirm the requirements, running costs and deployment recommendations.

Grass selection

Grass selection will be influenced by the climate conditions of the site, the nature of the construction that is used, the required quality of the pitch, maintenance resources, and the amount and quality of the irrigation water that is available.

Warm-season grasses should be used, with the main options being bermudagrass (*Cynodon* species) and possibly seashore paspalum (*Paspalum vaginatum*), particularly if salinity levels are very high.

Although warm-season grasses are generally used, the lack of cloud cover can lead to a significant drop in temperatures at night. For areas at the edge of this climate zone, or particularly where temperatures are lower at higher altitudes, the possible use of cool-season grasses may have to be considered for the cooler part of the year.

The selection of grasses in this type of climate is often a very significant factor influencing the quality of the pitch. Examination of other pitches in the area to see which grasses perform most effectively is very helpful, but additional information will also be required on the most appropriate varieties within each grass species.

It should be noted that in heavily shaded stadiums, grass growth may be very difficult with warm-season grasses. Therefore, very careful consideration should be given to the best grass selection in these circumstances.

Initial grass establishment

A number of approaches can be used and these will depend on the grass type that is selected. Seed can be used for some grass types, but many varieties are sterile and have to be established by either sprigging or turfing. For sprigging, the grass is developed from shredded pieces of the grass tissue which are pressed into the surface and then develop vegetatively by lateral spreading to give a full grass cover.

Sprigging and seeding are in most cases the preferred ways to establish grass cover as they are generally cheaper and avoid compatibility problems between the soil and the imported turf. However, establishment times for sprigging or seeding can be between eight and 20 weeks, depending on the grass species and weather conditions at the time of sprigging/seeding. Where sprigging or seeding is not practical because of the time available, grass establishment by turfing has to be considered. Turfed pitches rely on the grass being brought in as rolls from a suitable turf farm. It is essential that the grass and the soil in which it is grown are of appropriate quality, although sometimes a washed turf is used to avoid problems of compatibility with the rootzone on the site. The turf will usually require hollow tine aeration after laying to help drainage and root development. Establishment times for turfing operations will depend on the quality of the turf in terms of grass species and maturity, on the thickness of the turf rolls and on the quality of the laying. Typically five to seven weeks will be required before a pitch can be used, but shorter times can be achieved with thicker turf rolls (about 40mm) and very high-quality laying procedures.

Irrigation systems

Given the low rainfall in these zones, a very effective irrigation system is essential to support grass growth and retain a good grass colour. Irrigation may also be important for the preparation of a good-quality surface, for example to help to avoid excessive hardness.

In dry weather, irrigation requirements may reach 8-10mm per day (64-80 cubic metres for an 8000m² pitch) and sometimes more. In case of water supply failure, it is advisable to store this volume of water on site in tanks to give a safety margin of 24 hours until the water supply can be restored.

It is important that there is a reliable supply of water. This is often a borehole feed, but sometimes the mains water supply can also be used.

The design of the irrigation system is vital and it is important that water is applied uniformly. For this purpose, a good-quality, fully automated pop-up irrigation system is the preferred option. Usually, the minimum requirement is about 24 pop-up heads, but the better designs tend to have around 35 heads, with a full overlap between adjacent sprinklers.

An automated pop-up system also has major advantages in that water can be applied at night using a timer system, thus reducing evaporation losses.

In some areas there can be significant issues of water quality leading to problems of salinity. It is important that water quality is monitored at the outset of the project and if salinity is an issue, then management procedures must be modified to take into account the build-up of salts in the soil.

Pitch maintenance

Football pitches require regular maintenance to ensure that there is healthy grass growth and good recovery after use. The main maintenance operations are:

- **Mowing:** The frequency of grass cutting will depend on rates of grass growth, but for general-standard pitches cutting twice per week is usually appropriate, while more frequent cutting may be needed for high-quality pitches. Normal cutting heights are 25-35mm for general-standard pitches and 25-30mm for high-quality pitches.
- **Line marking:** The frequency of marking operations will usually depend on the level of use of the pitch and the standard of presentation that is needed. For good-quality pitches the lines must be remarked for each game, but for lower-grade surfaces three to four games or training sessions sometimes take place before the lines are remarked.
- **Aeration/spiking:** Aeration is performed to relieve compaction that builds up through play, to help water penetration and air exchange within the soil, to reduce organic matter accumulation at the surface, to help root development, and to reduce the hardness of playing surfaces. Typically, aeration will be carried out at three- to six-week intervals and may include both shallow aeration in the top 100mm and less frequent, deeper aeration to 200mm or more (perhaps once to three times per year). Hollow coring, in conjunction with sand dressing, is often used as part of the programme to control the build-up of organic matter. Extreme care is needed in very hot conditions to ensure that aeration does not lead to localised drying and damage to the grass plant.
- **Organic matter control through scarifying:** There is usually strong grass growth for most of the year which can result in an accumulation of organic matter at the pitch surface. This can affect the firmness of the surface, ball rebound and roll and may reduce drainage performance. Excess organic matter can be removed through various scarifying, raking and verticutting operations. The required frequency largely depends on the amount of growth and the level of use of the pitch. Again, extreme care is needed if the grass is under stress during particularly hot conditions.
- **Top dressing with sand:** Sand applications (sometimes incorporating soil or organic and inorganic amendment materials) are carried out to improve surface levels, to dilute the build-up of fine organic or mineral material at the surface and to improve surface firmness. Typically, 40-60 tonnes per pitch are applied annually in two to four applications.
- **Fertiliser application:** The application of fertiliser is essential to sustain the growth and recovery of the grass, with the most important nutrients being nitrogen, phosphorus and potassium. There is a wide range of fertiliser types and it is important to select a fertiliser programme that can sustain steady levels of growth rather than causing flushes of growth and then periods of poor grass development. Fertiliser applications are strongly influenced by soil type and temperatures, so more fertiliser will be needed on sandy soils and during the main growing season than during the cooler months of the year. On soil-based pitches, fertiliser may be needed at four- to six-week intervals. However, for a high-quality pitch on a sand-dominated rootzone, suitable fertilisers will generally need to be applied at two- to four-week intervals when growth is active.

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- **Pest control:** The main turf pests are usually insects (often the larval forms), but there is sometimes damage by birds or mammals usually when they are digging for insects or their larvae. Good turf management can be used as a cultural control to reduce the risk or symptoms of damage by pests, but a range of pesticides are also available.

Renovation

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