

# Preparation of a Sub-base for a Football Turf System

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**FIFA**<sup>®</sup>

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## Introduction

The FIFA Quality Programme for Football Turf aims to improve the quality of artificial football turf pitches produced and installed throughout the world. By testing artificial football turf installations in accordance with a stringent set of testing requirements in both a lab and field environment, artificial turf manufacturers who are licensed by FIFA can receive a FIFA field certificate for their successfully tested installations. With the provision of such a field certificate, FIFA confirms that the installation meets all requirements with regard to quality and performance.

FIFA constantly strives to improve the quality of artificial turf pitches all around the world by holding seminars, introducing new test methods and communicating closely with installers, manufacturers and test institutes.

It has, however, come to FIFA's attention that the quality of sub-bases across a wide range of pitches has been affecting the final quality of both FIFA Quality Pro and FIFA Quality pitches after a period of time post-installation. Similar feedback has also been received from multiple member associations and Local Organising Committees. With the use of artificial turf becoming more and more popular worldwide, it is becoming increasingly important to ensure that pitches obtain the highest quality possible over the lifetime of the pitch.

Consequently, FIFA has drafted the following document as a best practice guide to provide advice on the construction of the sub-base layers in different climate zones and target areas such as drainage, planarity and compaction levels.

## Ground inspection

Before designing a turf installation including a drainage network, each turf manufacturer needs to conduct a ground inspection to ensure that all factors that might have an influence on the construction work and the final installation are recorded and taken into consideration during the design phase.

### Topographic survey

A topographic survey will show the slopes, heights and depths of the undulations of the existing ground (and surroundings) upon which the pitch is to be installed. These are used along with a soil survey and climatic considerations to design the sub-base by determining the amount of soil that needs to be removed to form a stable sub-grade, which can then be profiled to the overall slopes of the finished pitch.

### Stability and permeability of the pitch location

A soil survey to identify the stability and permeability of the existing ground should be conducted by digging holes at different locations (a minimum of five) in the field and to identify the layers and their stability. To test the permeability of the ground, the location can be flooded with water to check the drainage capability.

### Drainage system

- Check if water-collecting systems are already installed (ditch, collector network) and, if so, check their condition (cleanliness, sustainability, etc.)
- Check if there are any water outlets which could be used for the project
- Check for water points in the nearby environment (rivers, sources, lakes, etc.)

### History of the site

A full overview of the site history is essential as this will provide viable information about potential risks such as flooding. Additionally, it should be identified if there are any cables, pipes, old building foundations, dumps, etc. in the ground which would have a significant effect on the construction of the sub-base and drainage network.

## Excavation of humus

Humus is the material that forms in soil from the decay of vegetable and animal matter. As such, it is the growth medium for vegetation, fungi and bacteria. Humus has very little strength from a civil engineering perspective and it is essential to ensure that it is correctly prepared to ensure the following layers are not negatively affected. Certain steps must be undertaken to ensure this:

- Removal of all possible vegetation from the project location
- Excavation of the organic topsoil layer in order to reach the subsoil layer. This will reduce the chance of possible growth of vegetation on the sub-base layer beneath

This should be done with the use of excavators or other similar machinery.

## Drainage

The drainage of football surfaces is essential as it guarantees an optimal playing performance during rainfall. The drainage network collects and removes excess water as quickly as possible from the field of play and potentially from the concrete surroundings.

If the water discharging from the drainage is clean, it can be collected and re-used for other operations in connection with the field such as for watering the pitch or the surroundings, and if it is filtered it may also be suitable for showering or cleaning.

### Drainage types

#### Vertical drainage

Vertical drainage systems are installed in the sub-grade as a network of channels. Prior to the installation, the installer needs to check the slopes and evenness of the sub-grade.

The channels must be installed in such a way that they collect the water coming through the sub-base, and should be ideally designed in a way that minimises the distance for the collected water to flow to the peripheral drainage channels around the field. The slope <sup>[1]</sup> of the channels is not parallel to the slope of the sub-grade. To improve efficiency and sustainability, the sub-grade between the channels can be waterproofed. Before the installation of the pipes, all channels need to be clean. To prevent contamination from finer particles that may wash out of the sub-grade, the channels should be excavated and laid out and lined with geotextile. The top of the channels must be left open and in contact with the sub-base.

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<sup>[1]</sup> Channel and pipe characteristics defined in Annexe 1

All pipes must be connected to a peripheral collector or directly to a ditch. To ensure that water discharges efficiently, ensure that the pipes connect at the top of the peripheral collector. For maintenance reasons, the diameter of the collector should not be less than 120mm and control chambers must be installed at a maximum distance of 60m for ease of inspections and cleaning.

To avoid damaging the drain (due to construction traffic, deformations, etc.) during the construction work, a base cannot be left without a water discharge solution (permanent or temporary), and all drainage installations must be designed backwards from the outlets.

When a local sewerage network is available, the drainage network must be connected via a chamber that has been adapted to allow video inspections and cleaning tools. When it is not possible to connect to a local sewerage network, ditches or pits can be created. This solution can be implemented only if the natural soil infiltration has been checked and if the level water ground is compatible. The size of such ditches or pits must take the climatic conditions and the water infiltration rate of the natural ground into consideration.

To ensure a consistent drainage over the whole pitch, the thickness of the layers installed above the drainage system must be relatively even.

### Horizontal drainage

Horizontal drainage is an alternative to traditional vertical drainage systems and can be used in areas with light precipitation where permeable sub-base materials are not indigenous to the area where the field has been constructed. In this case, the drainage system is either on top of the sub-base or immediately below the artificial turf, or the rainfall flows through the infill material and flows off the field on top of the impermeable backing of the football turf that has been specifically produced without its normal drainage perforations. If this drainage method is used, it is important to protect the sub-base from the water and install an impermeable layer between the top of the sub-base and the underside of either the horizontal drainage layer or the underside of the impermeable football turf. This could be a geotextile membrane, a foil or the artificial turf carpet if it does not have drainage holes.

For maintenance reasons, the diameter of the peripheral drainage channels should be at least 120mm and control chambers should be installed every 60m for inspection and cleaning.

### Rain climate zones

The world can be divided into several climatological zones regarding rainfall.

**Areas of low precipitation** require no sub-surface drainage. In fact, some areas receive so little precipitation that even a perimeter drain is superfluous.

**Areas of light precipitation** require a perimeter drain only. Impermeable bases tend to use impermeable membranes in conjunction with impermeable turf and rely on perimeter drains to evacuate the water from the field. In such circumstances, it is imperative that the slopes at the apexes are designed with the FQP planarity requirements in mind, and as such, the slopes need to be increased from a minimum to the maximum slope over a distance of several metres.

**Temperate zones** that normally lie between the tropics and the Arctic/Antarctic regions require sub-surface and perimeter drains, if permeable sub-base materials are available, the centres for which are in accordance with the degree of maximum rainfall known to occur in the specific location.

**Tropical rainforests and areas subject to monsoons and typhoons**, which generally lie between the tropics and the Equator, require sub-surface perimeter and sub-surface drains, if permeable sub-base materials are available; the centres between successive drains will be significantly closer than for temperate zones and will usually have additional larger drainage outlets to cope with heavier downpours.

## Installation

Drains are installed into the sub-grade immediately below the sub-base. It is important that the drainage channels are encased in geotextile to prevent contamination of the drainage aggregate and drainage pipes from finer particles that may wash out of the sub-grade and potentially the sub-base.

To ensure the drainage was installed correctly and permeability through all layers, it is mandatory to test the drain before the installation of the field.


## Stabilisation of sub-grade

The sub-grade layer is an essential part of the sub-base. If this layer is not fully stable, the whole instalment could be affected. If the sub-grade is not correctly prepared the first time round and a problem is found at a later stage, the layers installed above it will have to be removed before the problem can be fixed.

- Consolidate
  - It is recommended to excavate all material until a stable layer is found, which can be seen as a layer with a California Bearing Ratio (CBR) reading of >5%.
  - If the CBR reading is <2%, it is recommended that a new location be selected as the site is not sufficiently stable and will cause significant problems in the future.
  - If the CBR reading is <5% and >2%, there are certain steps which may be taken in order to achieve a CBR reading of >5%.

When deciding on how to best approach the stabilisation of the sub-grade, it is first necessary to assess how unstable the area is after excavating the humus layer.

- To improve stability, a variety of materials can be used such as:
  - Cement (only if other options fail)
  - Crushed lava stone or quarry dust



Avoid using high sand content or granular materials

- Similar materials depending on the situation
- The materials then need to be distributed before being compacted using a vibratory roller. Some methods of distribution are:
  - Spreader
  - Plough
  - Laser levelling machine
  - Similar machinery

The aim of these stabilisation methods is to achieve a CBR of >5% which indicates that the sub-grade is sufficiently stable

## Consolidation of sub-grade

Consolidation means to bring separate parts together into one unified body. The sub-grade is the first level of the sub-base construction, and it is important that it is consolidated to ensure that there are sufficient compaction levels on which the rest of the construction can be installed.

- A vibrating roller should be used to consolidate the sub-grade, and it is advised that the roller has a minimum mass of 5,000kg. The sub-grade should be profiled using a grader and compacted and consolidated to achieve a 95% Proctor Density Level using the CBR or other similar methods.
- The first layer of the sub-grade should replicate the same slope that you aim to achieve for the final sub-base layer.
- The planarity of the final layer should be ≤20mm under a 3m straight edge.

## Geotextile membrane

Geotextiles are permeable fabrics which, when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain.

- A woven or non-woven geotextile should be used to increase bearing capacity and to prevent the contamination of the sub-grade into the sub-base.
- The geotextile membrane may be installed by hand or with the use of mechanical equipment, but there must be a minimum of 300mm overlap between adjacent rolls.



## Sub-base aggregates, materials and gradings

There are a variety of sub-base designs that are used globally. These vary in accordance with the indigenous aggregates that are available. The aim of the sub-base is to create a stable permeable platform onto which the football turf system can be installed. However, some indigenous materials are impermeable e.g. laterites in Africa and marl in the Caribbean. Sand and lava rock, both of which are generally deemed to be permeable, are used in the Netherlands and Belgium, whereas lava rock is also used in countries like Germany. The majority of the remaining areas around the world use the more traditional method of quarried aggregate. Aggregate for sub-bases is first blasted out of a layer of rock. The large pieces are then crushed into smaller pieces, which are then separated into various fractions for use.

### First layer

The first layer generally consists of the larger fraction of quarried aggregate. Each piece of aggregate is structurally strong but because of their large size, they do not pack closely together, leaving relatively large voids between each piece of aggregate. The large voids are good for permeability but lack cohesiveness and are therefore relatively integrally weak.

### Second layer

The second layer consists of a medium-sized fraction of the quarried aggregate. The smaller size slots into the interstices of the larger aggregate in the first layer, helping to create a more cohesive structure. Clearly, as the voids are reduced, so the permeability decreases somewhat.

### Third layer

The final layer, in combination with the first two layers, achieves the required evenness and planarity requirements. The planarity should be  $\leq 10\text{mm}$  under a 3m straight edge and should obtain a CBR level of 5%. The final layer uses the smallest fraction to close up the interstices whilst avoiding sealing the surface and rendering it impermeable. For this reason, it should be used only sparingly and not form a distinct separate layer which is both structurally weak and detrimental to the permeability of the finished sub-base.

### Permeability

Permeable sub-bases will allow water to flow vertically and horizontally. The vertical flow passes through the drainage hole in the turf through the interstices of the sub-base into the drains installed in the sub-grade before flowing out of the field into the drains located outside of the field. To achieve the maximum vertical drainage capacity, it has to be ensured that the permeability is ensured through all layers of the sub-base. The horizontal flow will follow the slopes of the surface to perimeter drains located around the edge of the field.

Impermeable surfaces do not allow the vertical flow of water through the sub-base. The water flows from the field along the slopes of the turf/sub-base to peripheral drains. In such a sub-base design, it is important that the surface planarity tolerance is increased to  $\leq 6\text{mm}$  under a 3m straightedge to avoid “bird baths” forming.

## Different temperate zones

Due to the increase in popularity of artificial turf pitches worldwide, it is important to understand the various challenges that must be faced in different climatic regions. For this reason, a list of recommendations for the four main zones has been created below. Included in this is a minimum requirement that should always be met and a recommended value that should be aimed for.

Layer/region	Temperate zones	Sub-Arctic	Monsoon regions	Impermeable bases
<b>First layer</b>	Minimum: 150mm Recommended: 150-200mm	Minimum: 200mm Recommended: 300-400mm (more in extreme areas)	Minimum: 150mm	Minimum: 150mm Recommended: 200mm
<b>Second layer</b>	Minimum: 50mm Recommended: 100mm	Minimum: 150mm Recommended: 200-300mm	Minimum: 50mm Recommended: 100-150mm	Minimum: 50mm Recommended: 100-150mm
<b>Third layer</b>		20-150mm with fine grain	20mm blinding layer	Impermeable textile with drainage mat on top
<b>Additional comments</b>		<ul style="list-style-type: none"> <li>The design should be adapted to avoid frost damage. Install heating where needed</li> <li>Planarity of second layer &lt;10mm over 3m</li> <li>Permeability 360mm/h</li> <li>Load test: 40MPa or Mod AASHTO 95% for compaction at dry density</li> </ul>	<ul style="list-style-type: none"> <li>Use of both subsoil drainage and surface drainage</li> <li>Planarity of second layer &lt;10mm over 3m</li> <li>Permeability 300mm/h</li> <li>Mod AASHTO 95% for compaction at dry density</li> </ul>	<ul style="list-style-type: none"> <li>Drainage channels on all sides of the fields</li> <li>Planarity of second layer &lt;10mm over 3m</li> <li>Minimum slope of sub-base 0.5% from centre towards the sides for running off rainwater into the drainage systems</li> <li>95% Mod AASHTO, ASTM standard</li> <li>Top of sub-base should be covered with a PE foil which is non-permeable before installing the turf rolls</li> </ul>

## Glossary

**Excavator:** a construction vehicle consisting of a boom, a bucket, a dipper and a rotating cab mounted on either tracks or wheels. It is used to dig out, or excavate, material from the ground. The excavating action of an excavator is hydraulically driven.

**CBR (California Bearing Ratio):** a penetration test used to assess the mechanical strength of sub-grades and sub-bases.

**Site survey:** an [inspection](#) of an area where work is proposed to gather information for a design or an estimate to complete the initial tasks required for a building activity. It can determine a precise location, access, best orientation for the site and the location of obstacles.

**Sub-base:** the levelled and compacted aggregate layer laid upon the top of the sub-grade that supports the surface layer(s) above it.

**Sub-grade:** the native material located under the construction once the humus has been removed.

## Annexe 1 – channel and pipe characteristics

<b>TRENCHES</b>	Deep	$\geq \emptyset$ drain + 0.15m minimum	
	Width	AND	$\geq \emptyset$ drain + 5D $\geq \emptyset$ drain + 0.05m
	Infill	AND	Gravels d / D 2 mm < d < 5mm D $\leq$ 25mm (D / d) > 2.5
	Slope		>0.5%
	Installation	AND	On geotextile From bottom to top: - rolled - semi-rolled - crushed
<b>PIPES</b>	Slope		>0.5%
	Installation	OR	Parallel to longitudinal axe Fish bones <45°
	Spacing (distance between pipes)	OR	$\leq$ 10m if $\emptyset \geq$ 65mm $\leq$ 7m if 50 < $\emptyset$ < 65mm