Sports Field Drainage

What are your options??

Ian Lacy
We could just build a Roof!!!!
Drainage issues, sometimes they creep up on you..... Silently!!!!
DRAINAGE

WHEN

WHY

WHERE

WHAT
Issues affecting drainage

- Weather/Climate
- Usage
- Finance
- Sports Field Maintenance
- Soil/Construction type
Assessment of the surface
Let's do the sciency bit First......
Let’s begin with the basics...!

\[ h = \frac{sv}{K} \frac{1}{1 - (v/k)} \frac{1}{\pi} \left\{ \ln \frac{s}{\pi r} + \sum_{m=1}^{\infty} \frac{1}{m} \left( \cos \frac{m2\pi r}{s} \right) \left( \coth \frac{m2\pi D}{s} - 1 \right) \right\} \]
Soil composition

- **SOIL SOLID**: 45% Mineral
- **SOIL VOID**: 30-20% Water and 20-30% Air
- **5% ORGANIC**

(Cranfield 2005)
Particle size

• SAND
  Coarse - rough granular particles
  2.00 - 0.020mm

• SILT
  Smooth - spherical particles
  0.02 - 0.002mm

• CLAY
  Flat - plate like particles
  < 0.002mm
Textural Classification

![Textural Classification Diagram]
If rain falls at a rate higher than the soil can absorb, then the following could occur:

- Surface run-off
- Excess lost through Drainage
- Surface damage

Irrigation needs to be applied at a rate less than the infiltration rate of the soil.
Infiltration rates of sports surface materials

Infiltration rate, mm/hr

Soil type

70/30 rootzone
60/40 rootzone
Sandy loam soil
Clay loam soil
Compacted clay soil

Infiltration rate, mm/hr

0
100
200
300
400
500
600
700
800
900
Soil Water

• **Field Capacity**: macro soil pores are empty of water owing to natural drainage. Micro pores still hold water against the force of gravity.

• **Permanent Wilting Point**: all available water has been extracted from the soil. Plant death now results.

• **Available Water**: water available to the plant held in the soil between Field Capacity and Permanent Wilting Point.
Water movement in soils
Surface water problems
Groundwater Drainage Problems

(a)

(b)
Its worth it......

Soil Volumetric Proportions

- Normal: 25% Air, 25% Water, 50% Solid
- Compacted: 5% Air, 25% Water, 70% Solid
- Poorly Drained: 5% Air, 45% Water, 50% Solid
Layering: Coarse over Fine
MOVEMENT OF WATER THROUGH SOILS
COARSE SOIL LARGE PORES

- water source
- gravity
- pressure
- matric forces
- fingerflow
Water Movement Through Coarse Textured Soils
MOVEMENT OF WATER THROUGH SOILS
FINE SOIL SMALL PORES

- Water source
- Gravity
- Pressure
- Osmotic forces
- Matric forces
- Gravity
Layering: Fine over Coarse
Movement of water through large pores (e.g. coarse sand)
MOVEMENT OF WATER THROUGH SOILS TOWARDS DRAINAGE OUTLET

Water source

Water table has to rise to allow drains to flow
The why??
Why do we need drainage?
Why do surfaces fail?

- Specification
- Construction
- Management/maintenance
Poor specification or maintenance?
Where has all this water come from....?
Water water everywhere
How Much..?

(Football pitch approx 7,500m²)

1mm of rain = 70 tonnes of water.
Snow!!!!!!
More Snow!
Why do we need drainage?

- Saturated / Wet Rootzone
  - Poor recovery
  - Surface ponding and instability
  - Play Cancelled (revenue lost)
- Low rootzone strength and poor turf
Increasing prizes/penalties

Abandonment of major events:

• Test matches - £4M
• Major horse race - £17M
• Premier football match - £0.5M

• Cost of injury
• Players (e.g. W - £20M?)
• Horses - £10M

• Local level a championship team reduced player injury from 24 hospitalised injuries to 7 in the same time period after installation of new pitch
Thatch

- Is the build up of partially decomposed organic matter in the upper profile of the rootzone.
- Factors that encourage this;

Poor drainage

Excessive fertilizer applications
Dramatic lowering of mowing height
Poa annua
Only 20% comes from returned grass clippings
The effects of thatch
Identification of the cause of drainage problems...

• Is there existing drainage infrastructure? - Is it working?
Capping over sand slit
Carry out an investigation!

"Great. You found my septic tank."
Poor playing surfaces

- Reduced enjoyment at all levels
- Games called off, courses closed
- Poor/erratic playability
- Dangerous situations
- Poor technique
- Liability
- Lost revenue
Surface-water or Groundwater?

- Groundwater problems
  - High/rising water tables
  - Confined aquifers
  - Temporary water table

- Surface-water problems (can be up to 80% of problems*)
  - Poor infiltration rate
  - Excess/ high intensity rainfall
  - Perched/suspended water tables
  - Saturated ground conditions
  - Watershed problems

*estimate, based on consultancy cases
Identification of the cause of drainage problems...

• Dig a hole!
  – Does the water appear at the bottom of the hole and move upwards?
  – Do you have coarse-over-fine or fine-over-coarse?
  – Soil structure - are there impermeable layers (e.g. compaction)?
  – Is there any evidence of black layer or mottling?
Inadequate outfall
Orientation of surface drains
Poor conditions
Identification of the cause of drainage problems...

- Look around you
  - How does the land lie – where are the slopes?
  - Is water being shed into the area from other areas?
Identification of the cause of drainage problems...

• Is there existing drainage infrastructure? - Is it working?
**Identification of the cause of drainage problems...**

- Is there existing drainage infrastructure?
  - Is it working?
Identifying cost effective alternatives

• Need a solution that is both:

  - Cost effective (principally through reduced cost)

  and

  – Achieves a minimum drainage performance
What about the cost??

Problem looks like surface water

Sand slit solution = £18 000 /pitch + on-going maintenance

4 x pitches, solution = £100 000

Problem turns out to be groundwater:

Groundwater pipe solution = £25 000 /pitch

4 x pitches, solution = £100 000
What about the cost??

Full pipe Installation on a football/soccer pitch 7500m²:
Including the following:

- Catch water/interceptor drain
- Main Drains
- Laterals @ 5m centres

Average cost £20-25 000
What about the cost??

- Sand Slits [pure sand] @ 1m centres =
  Average cost £18-20 000

- Sand Slits [50% gravel-50% sand] @ 1m centres=
  Average cost £15-18 000

- Sand bands @ 30cm centres =
  Average cost £5 000
What about the cost??

- Mole ploughing @ 1m centres
  Average cost £3-5 000

- Sports turf maintenance
  Average cost £10 00 per annum
Specification

Natural soil - can produce good surfaces but variability in soil properties

• Constructed soils-specifications for:
• Blend of soil particle sizes
• Blends to be used for different layers
• Mechanical strength
• Water movement

Is a perched water table construction appropriate?
Determine the issues - Slope/Grade
Weather data average
Concerts !!!
Concerts!!!!!
The good old days!!
Beauty and the beast!!!
Factors affecting drainage:

- Type of Rootzone/Soil
- Surface levels/Gradient
- Compaction
- Groundwater levels
THE
WHAT?
**Drainage suitability for soil types**

Different soil types require a different drainage approach

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Mole Drainage</th>
<th>Mole Drainage lined</th>
<th>Sand Grooving</th>
<th>Sand slitting piped</th>
<th>Lateral Collectors</th>
<th>Carrier</th>
<th>Decompacting</th>
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**Key**

- Optional
- Recommended
PERFORATED COLLECTOR

4" Perf drain tile with pea gravel and sand backfill (TYP)

15 FT (TYP)

0.1 TO 0.5% SLOPE (TYP)
Incorporation of recycled compost
Organic matter incorporation

- Some soils, specifically silts and sandy silt loams, become de-structured due to excessive play and pedestrian/machinery traffic.

- Therefore, the use of organic matter incorporated in to the profile may improve surface structure thus drainage and performance.

- This material, whilst having significant benefits to performance of the playing surface, can be obtained very cheaply from recycled green waste.
Aeration equipment
Sports Field Maintenance

- Soil Survey/sampling.
- Setting Out/Marking out.
- Mowing.
- Aeration.
- Scarification/Verti-cutting.
- Brushing/Drag-matting/Harrowing.
- Rolling.
- Irrigation.
- Fertilising.
- Seeding.
- Top dressing
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Soil survey/sampling
Pitch Assessment
Aeration

- Suitable for localised work
- Not practical for larger areas
Aeration
Aeration
Aeration
Aeration

• Deeper rooting; creates pore spaces for root activity.

• Improved infiltration of water, air & fertilizer.
Aeration tines

Solid  Solid  Chisel  Hollow  Hollow  Jumbo Hollow
Linear Aeration equipment
Linear Aeration equipment
Compaction Relief - Earthquake
Verticutting/Scarification

- Verticutting: Between the leaves of the plant
- Scarification: Cutting into the rootzone

(SISIS 2007)
Scarification?
Removal of excess surface water
Mole Drainage

• Most drainage problems associated with heavy soils tend to be caused by poor surface infiltration.

• The most commonly adopted method for removing surface water is sand slitting into an existing drainage infrastructure.

• However, mole draining is a cost effective alternative to this approach and gives the following advantages;
  
  – Increasing infiltration rates
  – reduces surface ponding,
  – increases playability and
  – reduces pitch wear.
Mole drainage

Advantages
Very affordable equipment.
Low skill level (1 man operative).
Very affordable installation.
Repeatable.
Can last 5-8 years.
Minimum top dressing required.
Ready for play immediately.
Can be done without an existing infrastructure.
No arisings

Disadvantages
Soils can crack badly if undertaken in wrong conditions.
Correct machinery has to be used specific sports mole drainage systems plus top surface management systems
Narrow window of installation.
Soil type specific.
Mole drainage

Mole ploughs offer a cheaper surface drainage solution for pitches on indigenous soils with a high clay content.
A typical mole plough design

Cracks created by the mole plough allow movement of water through the profile.

Mole channel
Mole plough foot
Aeration: Groundbreaker
Sand slitting

Advantages
Very effective in all soils.
Can last 10 years.
Wide window of installation.

Disadvantages
Expensive to install and maintain.
Can last only 1 season if not maintained correctly.
Sinkage due to shrinkage of soils.
Arising's up to 140 tonnes per pitch
Sand depth critical.
3 man operation.
Not ready for play until grass cover complete.
Requires existing or new main drainage infrastructure.
Surface-water solutions

- Sand slitting / gravel banding
Surface-water solutions
Sand slit excavation
Installing sand slits
Sand slits

(c) Cranfield University (NSRI), 2004
Topping up sand slits
**Sand slits**

Lateral drain spacing
5m

Sand slit spacing
1-2m

Sand Slit Detail

- 50mm sharp sand/grit
- Φ80mm perforated pipe
- 90mm
- 500mm
- 100-150mm topsoil/rootzone
- 10-20mm pea gravel
Sand Banding
Sand banding
**Trench and pipe drainage**

Certain soils will require a full interceptor, lateral and carrier drainage system. Calculations show that the conventional 80 mm pipe is oversized for conventional sports pitch drainage.

The table below shows the diameter size of lateral pipe for a range of spacings on a full size football pitch for 30 mm of rainfall per day.

Groundsman use micro pipes at the base of all their interceptor drains (sand slits) as well as reducing the size of the lateral drains. This means less arisings and less cost without compromising drainage efficiency.

<table>
<thead>
<tr>
<th>Diameter of pipe at grade (mm)</th>
<th>Lateral spacings (m)</th>
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<tbody>
<tr>
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<td>6 m</td>
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<td>≤ 20</td>
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<tr>
<td>0.1%</td>
<td>≤ 30</td>
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</tbody>
</table>

Source: ADAS FDEU Nomographs
Drain trenching equipment
Pipe drainage
Installing pipe drainage
Main drain cutting and laying
Pipe drain backfill
Consolidation of backfill
Effect of depth on drain spacing
Effect of depth on drain spacing

Dry

Dry

Dry

0.5m

Dry

Dry

Dry
Effect of depth on drain spacing

1 m
Surface water problems – bypass drainage solutions
Where coarse porous backfill material is used, it may be necessary to include a 50 mm deep blinding layer of coarse sand or grit to prevent ingress of rootzone into the porous backfill.

Pipe drains at 5 – 10 m centres.
Pipe drainage and slit drainage construction on cultivated topsoil.

A direct hydraulic connection between the slit drain and backfill above pipe drain is essential.
Where coarse porous backfill material is used, it may be necessary to include a 50 mm deep blinding layer of coarse sand or grit to prevent ingress of rootzone into the porous backfill.

- Each application of dressing should be in the region of 60-100 tonnes, depending on the size of pitch.

Pipe drainage construction on cultivated topsoil with supplementary sand grooving.
Materials
Herringbone system
Herringbone
Sub air!!!!!!
Sub air!!!!!!
THE

Where?
A plans what we need..
X marks the spot
A Feasibility Study

- The Planning Process
- Planning Policy Guidance
- Development Plans
- Environmental Assessment
- Geographic Area and Demand.
- Assessment of Existing Facilities
- Specific Location
- Current Land Use
- Land Area
- Landscape Quality Assessment
- Type and Proposed Scale of Development/design
Which way to go
Specification

Natural soil - can produce good surfaces but variability in soil properties

- Constructed soils - specifications for:
- Blend of soil particle sizes
- Blends to be used for different layers
- Mechanical strength
- Water movement

Is a perched water table construction appropriate?
Construction

Can dictate ultimate success or failure

• Adhering to the specifications?
• Moisture status during construction?
• Keying in layers?
• Development of good rootzone?
Construction

Can dictate ultimate success or failure

• What does it cost?
• Who designed it?
• How do you tender?
Construction

Can dictate ultimate success or failure

- What does it cost?
- Who designed it?
- How do you tender?
- Have the drainage issues been identified correctly?
Construction
Construction

Can dictate ultimate success or failure

• What does it cost?
• Who designed it?
• How do you tender?
• Have the drainage issues been identified correctly?
• What type of drainage; pipes or moles, or pipes and slits or both?
Construction-installation of subbase pipe drainage
Pipe installation
Laser levelling of lower rootzone
Distribution of upper rootzone
Consolidation of upper rootzone
Laser leveling upper rootzone
The Results?
A winning formula..
What a result..
Testing, Testing, Testing......
And Remember after construction......

Be vigilant for any unusual behavior from nature
THE
When?
Prevention better than cure

• Surface water problems:
  – Try and keep infiltration rates above approx 15 mm/day
  – Keep the surface open – harrowing, decompaction etc.
  – Encourage and look after grass roots
  – Herd management – rotation of pitches, defining walkways, controlling practice areas.
  – Understand your soils and their structure
  – Managing hydrophobicity
  – Control watershed onto sports surfaces
Prevention better than cure

- Ground water problems:
  - Divert water supply sources (springs etc)
  - Check and clear outfall
  - Check and maintain drainage network
  - Understand your soils and their structure
Problems and solutions

• Groundsman need to tailor the solution to the drainage problem which is why all projects start with a diagnosis.

• Different soils will have very different drainage properties and will therefore require a unique design approach to the solution.

• Managing “groundwater” drainage is managing “top water” drainage.
THE Future?
Aeration equipment