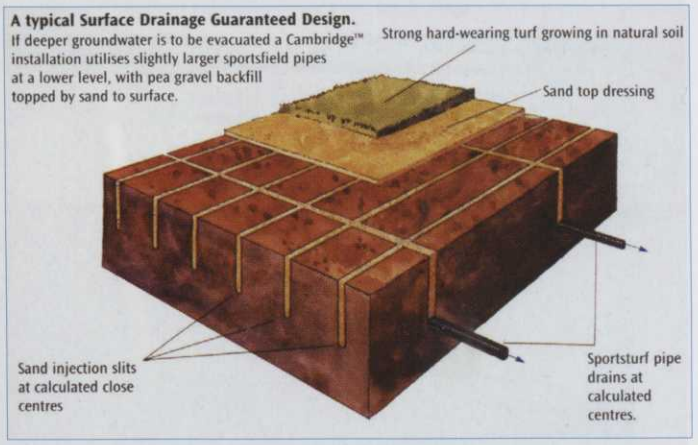
DRAINAGE - The Intensive Key

Geoffrey Davison unlocks the science behind effective sportsturf drainage.

It's Simple - You put in pipe drains and they take away the water! But, how many pipes, of what sizes, at what centres, at what depths and with what backfill? And, crucially, how does surface water reach the pipes and how quickly can it get there?



▲ A typical surface drainage installation

A decades long history of failures and shortcomings showed that achieving the high drainage standards needed for sports activities is not at all simple but, in fact, is a demanding challenge.

Films and photographs from only, comparatively, a few years ago show football, rugby, golf and racing taking place on badly waterlogged ground. We wallowed in mud and accepted that it was an inevitable part of outdoor sports activities, especially during winter. Pipe drains were often under the ground but even a moderate rainfall led to a mud bath on a soaked and slippery surface.

The advent of televised sport brought about a fundamental change, due to two factors. The viewing public wanted to see good green turf on their screens, and money on a previously undreamt scale became available to sport from television rights.

There was an urgent need for superior drainage and also funds to pay for it. But the necessary 'know-how' just did not exist. Existing drainage was traditionally 'agricultural' - satisfactory for farming, but totally incapable of providing the rapid drainage rates required for fulfilling fixture lists on good green turf no matter what the weather.

A new science and technology had to be created. Research and development produced valid theories and from these a practical technology has been evolved, but it has been a trial and error process. Mistakes and shortcomings were inevitable and some of the lessons have not yet been universally appreciated.

We now have formulae which provide a mathematically calculated basis for designing fully cost-effective sportsturf drainage schemes. The calculations can be applied to all aspects of any installation; the required pipe sizes, depths, lengths, gradients and spacings can all be accurately stated. The stated permeability rates for each and every one of a scheme's component elements needed for water to reach the pipes rapidly is another very essential part of a properly calculated design. Hence 'The Intensive Key'.

So many installations have not been calculated - in fact they have been installed on a hit and miss, hope to get it right, basis. Almost invariably they do not cope with the amount of rainfall, which is bound to occur, and the excuse is always that the rain has been exceptional, when in fact it was just typically heavy, as should have been expected. With more drains and better permeability, that is if the scheme had been more intensive, it would have provided a higher drainage rate.

In designing any practical sportsturf scheme there is a choice between just two alternative principles - either a 'Designed Profile' or a 'Drainage Matrix'.

The most common use of the very expensive Designed Profile technique is in golf green construction, although in recent years some major stadia have had such installations. The existing soil is removed and replaced by layers of gravel, sand and pre-mixed permeable rootzone material. Pipe drains are placed under the gravel layer and efficient irrigation is essential. Installation is a major disruption and subsequently, very high standards of maintenance are required.

The precise composition and depths of carefully tested materials are crucial. All too often, in order to keep down costs, more 'convenient' and/or cheaper materials have been employed. Unfortunately, even minor deviations in particle size content or material depths can cause serious defects.

Golf greens constructed precisely to proven standards, such as the USGA Green specification, can be excellent, whereas there have been a number of greens which purport to be to this standard but which have been very disappointing because detailed proven specifications has not been fully complied with.

The Drainage Matrix is a valid lower cost alternative to the Designed Profile, providing that the 'Intensive Key' is applied. With appropriate variations, the Matrix principle can be successful for all types of sportsturf, including golf greens and fairways, football, racing and rugby.

A calculated drainage facility is imposed into what may be a fertile but fairly impermeable in-situ soil. Instead of water being required to pass through the soil to set to the pipe drains, it is provided with a very effective and quick by-pass route. Again an appropriately intensive design is the key to success.

On a golf green, a good scheme would provide not less than four linear metres of drainage for every one metre of surface area. A similar degree of intensity may be needed on areas such as soccer goal mouths, centre circles,

▲ Cutting wheel for neat narrow trenching

▲ Profound aeration creates countless millions of tiny cracks and fissures

the bends of race courses and individual wet patches, whereas areas such as fairways may generally need rather less intensive treatment.

A high proportion of the Drainage Matrix schemes which have been installed have not been sufficiently intensive to achieve the hoped for results. There are examples where, under the general description of sand-slitting and without any calculations being made, trenches at perhaps 3m or even 5m centres have been dug across existing drains at 10 or 20 metre centres and then back-filled with building sand, selected because of a low price and without regard to its permeability.

There may be some little benefit to the drainage, but this does not start to compare with the performance achievable from a correct design. Unduly, low budgets certainly have often prevented fully effective installations being carried out, but two other factors have also been responsible; namely the lack of relevant expertise and the non-availability of suitable specialised equipment.

Technology has moved on. Effective machines are now available and there is a much better general understanding of the problems and remedies. The crucial importance of the right sand is now recognised. Some machines cannot place and consolidate sand into narrow trenches and therefore the manufactures have claimed that grit or granules can be used.

This may be good sales talk but it is not sound technology. The short term drainage benefits rapidly decline as fines easily infiltrate into the larger pore spaces of such materials. Furthermore, the addition of grit, fine gravel or granules is seriously detrimental to a soil's texture, whereas the systematic addition of good sand steadily improves it.

All schemes need an intensive key to be successful; under-design makes performance shortcomings inevitable. Whether it is a £1,000,000 stadium pitch, a £30,000 USGA specification green, a £10,000 improvement to a playing field or a £5,0000 high capacity drainage installation in a golf green, they all need to be based on sound, suitably intensive designs which exactly state what detailed measures are required to create a defined drainage capability.

Sportsturf Drainage has been and still is my life-long work and interest. I am always happy to have a telephone discussion about any aspect. My number is 01568 797024.

AN OUTLINE OF THE MATHEMATICAL BASIS OF DRAINAGE DESIGN

MAXIMUM LENGTH OF PIPES TO DISCHARGE POINTS

$$M = \frac{F}{V S}$$

M = maximum length in m
F = pipe manufacturer's flow rate in L/hr
V = scheme design rate mm/hr
S = distance between pipes in m

DESIGN BASIS

Accepting the established formula

$$S = \sqrt{\frac{h^2 4K}{V}} \therefore V = \frac{h^2 4K}{S^2} \therefore K = \frac{V S^2}{4h^2}$$

The notations which are applied must be varied for each component part of a drainage design and varied again for each different type of design

APPLYING THE FORMULA FOR SUB-SOIL EVACUATION

S = distance between pipes
h = depth of pipes (or depth at which the permeable back-fill over the pipe meets a different soil)
4 = a constant
K = hydraulic conductivity of the in-situ soil
V = designed drainage capacity

APPLYING THE FORMULA FOR SAND-SLITS

When applied to the slits of an inter-connecting sand/or sand-gravel matrix, the same equation requires the notations:

S = distance water travels laterally in the slits to reach discharge
h = depth of slit
4 = a constant
K = hydraulic conductivity of slit back-fill material
V = designed drainage capacity which needs to be adjusted by the fraction of the width of slits in proportion to the distance between them, ie

$$V = \frac{\text{width of slit}}{\text{Distance between slits}}$$

THE SIZE AND SURFACE AREAS OF SOIL PARTICLES

Particle type	Diameter (mm)	Approx number of particles per gram	Surface area of particles in 1g (cm^2)
Very coarse sand	2.00 1.00	90	10
Coarse sand	1.00 0.50	700	20
Medium sand	0.50 0.25	6,000	50
Fine sand	0.25 0.10	50,000	100
Very fine sand	0.10 0.05	750,000	250
Silt	0.05 0.002	6,000,000	500
Clay	less than 0.002	90,000,000,000	8,000,000

Note the huge difference in size between clay and other particles