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HIGHWAY DRAINAGE SYSTEMS

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INTRODUCTION

Appropriate drainage is an important feature of good highway design in terms of ensuring required level of service and value for money are achieved. Highway drainage has two major objectives: safety of the road user and longevity of the pavement. Speedy removal of surface water will help to ensure safe and comfortable conditions for the road user. Provision of effective sub-drainage will maximise longevity of the pavement and its associated earthworks. Highway drainage can therefore be broadly classified into two elements – surface run-off and sub-surface run-off: these two elements are not completely disparate in that some of the surface water may find its way into the road foundation through surfaces which are not completely impermeable thence requiring removal by sub-drainage. Based on these fundamental principles, drainage methods in the UK are broadly divided into two categories:

(a) combined systems, where the surface and sub-surface water are collected and transported in the same pipe, and
(b) separate systems, where the two elements are collected and transported in separate pipes

Within the broader definition of the two systems there are a number of different drainage methods that are in use on UK highways, some of them more common than others. Each method has its advantages and disadvantages and some may be more suitable in certain situations than the others. This paper describes some of the most common methods and provides an overview on their applications.

COMMON DRAINAGE METHODS

1. Kerb and Gullies

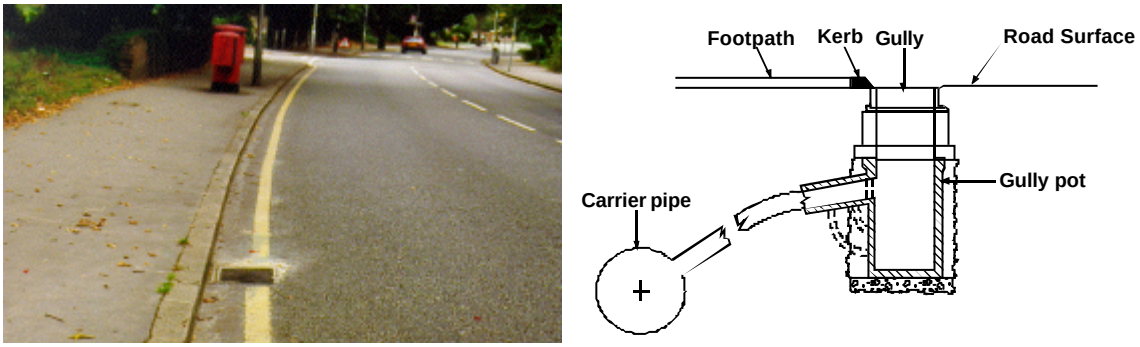

Figure 1: A typical scene of a kerb and gully drain and a layout of its construction.

Road surface drainage by kerbs and gullies is commonly used in the UK, particularly in urban and embankment conditions. The function of kerbs is not purely to act as a barrier to retain storm run-off from the road surface, they also provide some structural support during pavement construction and protect footpaths and verges from vehicular overrun. They are a safety hazard for high speed vehicles and are generally not suitable for use on trunk roads where speed is unlimited. However, limited use of them is allowed mainly in verges and in certain specific cases in the central reserve but with a height restriction of 75mm. One advantage of kerb and gullies is that its ability to carry road surface runoff to outfall is not dependent upon the longitudinal gradient of the road itself. Road gullies will generally discharge to longitudinal carrier pipes, which can be laid to fall independent of the road gradient to meet the required flow capacity.

2. Surface Water Channel:

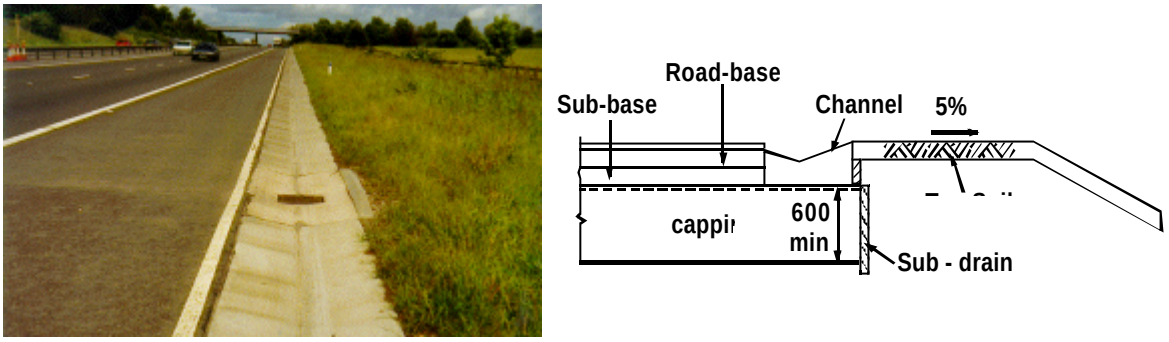

Figure 2: A typical scene of surface water channel drain and a layout of its construction.

Surface water channels are normally of triangular/trapezoidal concrete section, usually slip-formed, set at the edge of hard strip or hard shoulder and flush with the road surface. They provide an economic alternative to edge channels and are the Agency's preferred edge-drain solution for rural locations (trunk roads and motorways). However, they may not be appropriate for roads with long stretches of zero longitudinal gradients. They provide a positive means of keeping the surface water on the surface for most of its journey thus avoiding the possibility of large quantities of water entering the road foundation and causing premature failures. Long length of channels, devoid of interruptions, can be constructed quickly and fairly inexpensively using slip-form techniques. They are capable of carrying large volumes of water over long distances and channel outlets can be located at appreciable spacings and to coincide with watercourses thus avoiding the need for a separate carrier pipe. They are easy to maintain and any long-term problems developing can be detected and monitored by simple visual inspection from the surface. Research suggests that properly designed channels pose no greater hazard than other common drainage features such as kerbs, embankments and ditches, and in most situations are potentially less hazardous.

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3. Combined Filter Drain (French Drain):

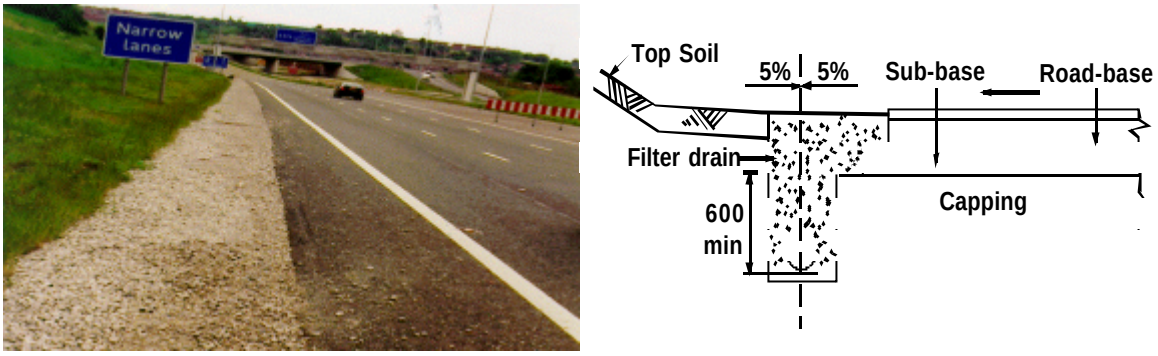

Figure 3: A typical scene of a combined filter drain and a layout of its construction.

This is a combined system using an aggregate-filled trench with a perforated or porous pipe at the bottom. The system commonly described as 'French drain' collects road run-offs through the top of the trench and sub-surface run-offs through the trench walls. Combined drains have been the traditional solution adopted for rural roads for many years and due to the very open texture of the filter material they provide for the rapid removal of rainwater from the road and verge surfaces. However, in performance terms, they have many disadvantages and for that reason the use of them in new constructions is generally not advocated by the Agency. Problems include: (a) stone scatter by vehicle over-runs, (b) surface failures of embankments caused by the extension of sub-base as a drainage layer, and (c) possible softening of foundation due to the drain becoming waterlogged at road foundation level causing long term deterioration. The Highways Agency is currently funding a number of research projects looking at the problem areas with a view to making greater use of the system, and it is emerging that the use of an alternative filter media with improved specification of the pipe and bedding construction may have the answer to some of the problems.

Notwithstanding the disadvantages, combined drains are likely to be the best solution in cuttings where predicted high ground water flows require removal. The relatively large hydraulic capacity required for dealing with surface water during heavy storms means that combined drains generally contain sufficient capacity to take any intercepted ground water as there is always a time lag between storm water flows and ground water flows.

4. Over-the-edge Drainage

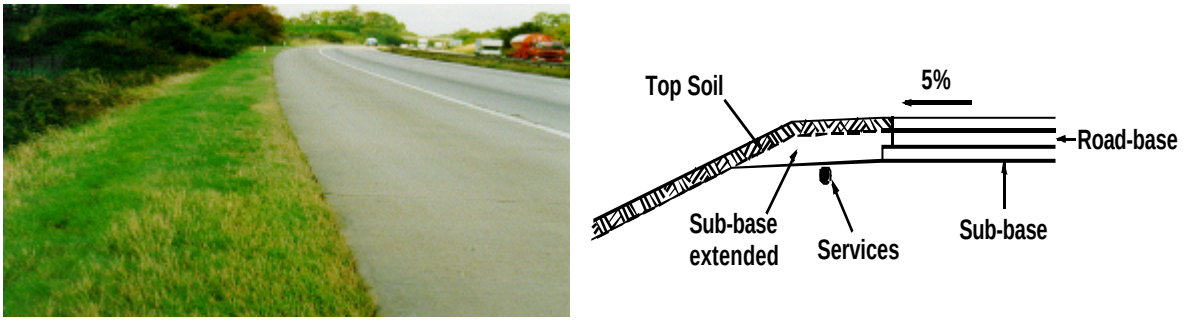

Figure 4: A typical scene of over-the-edge drainage and a layout of its construction

This method is applicable to embankment conditions where the carriageway surface water is allowed to drain over the edge and down the embankment slope directly into open ditches as appropriate. Over-the-edge drainage can cause soil erosion, topsoil slippage, softening of the side slopes and embankment instability. Its use is therefore only advocated in situations where the embankments are of low heights, shallow slopes and constructed of good quality granular material. It is inappropriate for use in locations where footways abut carriageways, on structures or on

embankments constructed on silty or clayey moisture susceptible soils. Weed growth on verges can inhibit free drainage.

5. Drainage Channel Blocks (and Grips):

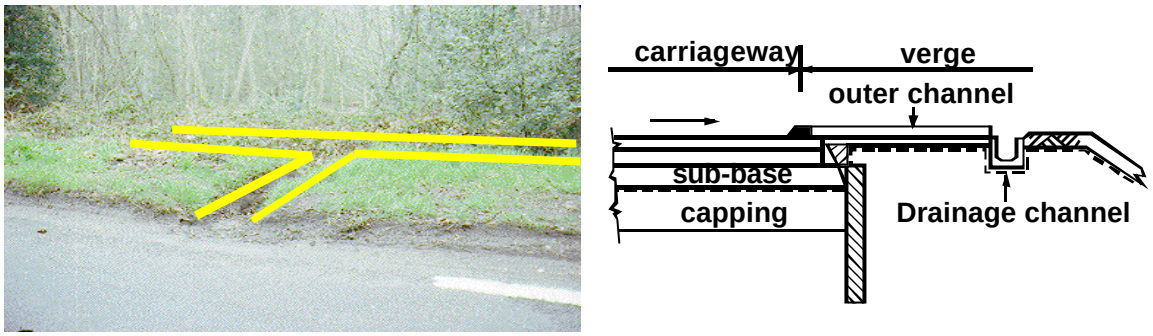

Figure 5: A typical scene of drainage channel blocks and a layout of its construction.

These are small channels across the verge, constructed of precast channel blocks in order to allow drainage collected along a kerb channel to drain across the verge into verge side ditches constructed of larger precast channels. They are not permitted as edge drains contiguous with hardshoulders, hardstrips or carriageways. There are potential maintenance difficulties associated with the use of the system. Settlement of adjacent unpaved surfaces would reduce their effectiveness. They may be prone to rapid build up of silt and debris in flat areas, and grass-cutting operations by mechanical plant will be jeopardised adjacent to the channel. Some minor roads are drained by "grips" which are basically the same arrangement but with the channels unlined. Grips and channel blocks should be avoided in verges subject to frequent equestrian usage.

6. Combined Kerb and Drainage Units:

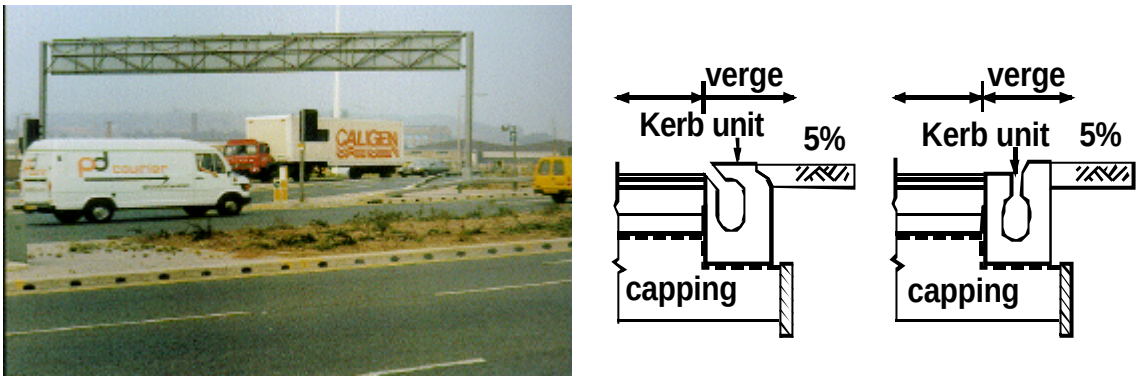

Figure 6: A typical scene of combined kerb and drainage unit scene and a layout of its construction.

These are special kerb units that allow lateral entry of surface water from the (kerb side) channel either continuously or intermittently into a continuous internal channel bore that acts as a carrier drain. They are usually constructed of precast concrete units either in one piece or comprised of a top and bottom section which when laid will form a continuous closed internal channel. The part of a unit projecting above road level acts as a kerb and contains a pre-formed hole, which admits water into the internal cavity. Units are typically 400-500mm long and the pre-formed holes thus occur at that spacing. They are especially useful where kerbs are necessary at locations of little or no longitudinal gradient, particularly at roundabouts. They can be useful where there are a number of public utility services, especially in urban areas. Despite their high cost of construction they may be economic in rock cuttings where carrier drain construction can be very expensive.

7. Linear Drainage Channels:

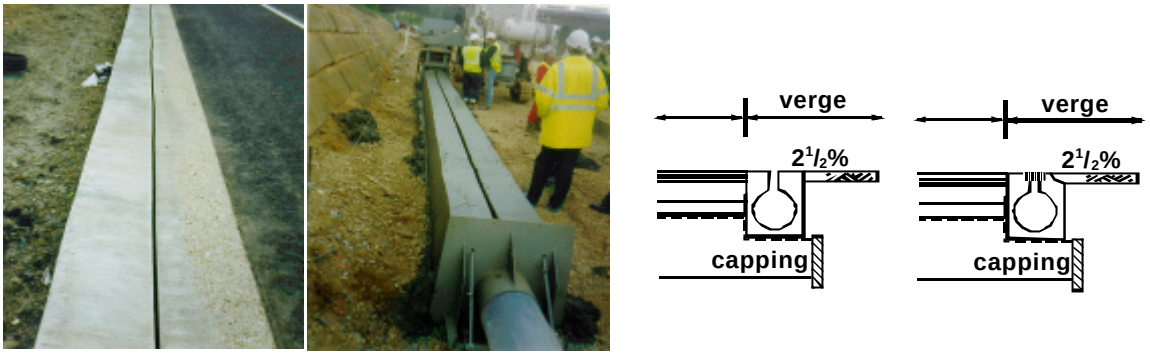

Figure 7: A typical scene of linear drainage channel and a layout of its construction.

These channels comprise of a longitudinal sub-surface closed profile hydraulic conduit, constructed of either precast units or in-situ concrete, into which surface water is drained via longitudinal or angled slots situated above the conduit. The top of the system will be flush with the adjacent surface from which surface water is drained. Precast units may be of concrete, glass reinforced concrete, polymer resins or similar materials. In-situ construction is usually of concrete using slip-form techniques. Although precast units in small sections of this type have been commercially available for many years, the construction of larger sections by slip-forming techniques is an innovative break through in highway application. The Highways Agency should take credit for publishing the first ever national standard permitting the use of the system. Construction of channels with internal bore diameters as large as 600mm have been shown to be possible with slipform construction. Large diameters are needed on trunk roads to cope with the road run-off because unlike in a conventional system the carrier pipe will have to follow the profile of the road, which in cases can be fairly shallow. Water entry is through a vertical slot usually continuous and slightly offset from the edge of the carriageway. The allowable range of slots is usually safe for all motor vehicles but there are limitations when it comes to areas where cyclists and pedestrians are allowed. These channels are an ideal solution in central reserves with Vertical Concrete Barriers (VCB)

8. Fin and Narrow Filter Drain (Sub-surface drainage):

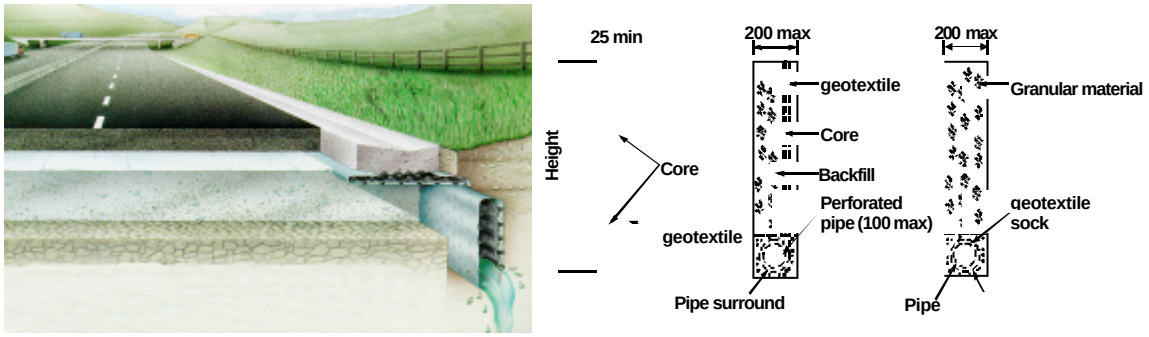

Figure 8: A three-dimensional artist's impression of how sub-surface drainage work and construction details of Fin and Narrow Filter drains.

These are intended to be the normal methods of sub-surface drainage on motorways and trunk roads usually installed longitudinally along the lower edges of road pavements. They act as low capacity filter drains to remove and keep out water from the road structure in order to ensure that the road structure does not fail prematurely by softening of the sub-grade. They also prevent

ingress of water from verge areas adjacent to the pavement. The Agency's standard construction details contain a number of different types of fin and narrow filter drains intended to give the contractor the widest possible choice of detail to suit the ground conditions. As there are no British or European Standards to cover this type of system the Agency has developed it's own and imposed a requirement for the system to be certified by the British Board of Agre'ment (BBA) or an equivalent body. The certification serves as a means of monitoring the continued compliance of the system. The system although very efficient and simple in its detail, can be very difficult to construct; some major difficulties were reported, particularly with narrow trenching and back filling when it was first introduced some ten years ago. With the passage of time the industry seem to be getting round the problem by adopting ingenious techniques such as minimum dig and trenchless installations. However, there is still room for the art to be perfected.

9. Edge Drainage for Porous Asphalt:

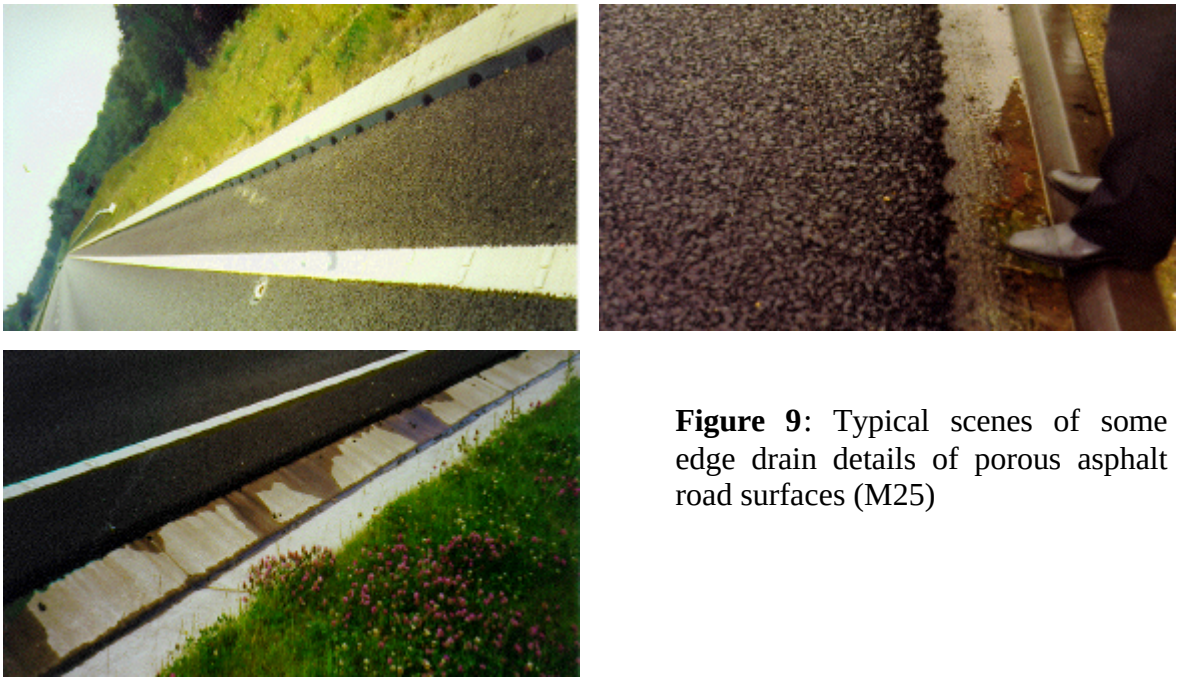

Figure 9: Typical scenes of some edge drain details of porous asphalt road surfaces (M25)

The use of porous asphalt on UK roads is primarily for the purpose of noise reduction but it has the added advantage of spray reduction, which enhances road safety. The open texture of porous asphalt with interconnecting voids which act as a drainage layer underneath the road surface makes it necessary to have a special edge detail for positive drainage. The fundamental difficulty with the edge drainage detail for porous asphalt is that the most efficient method of water removal requires an open free edge at edge of the carriageway. This is typically a 50mm step and if formed vertically may have undesirable safety implications for some road users. It is for this reason that the Agency's standard edge-drain details cannot be used without modification. The standard details have to be specially adopted taking into account the need to have a free edge and at the same time having regard to the safety of all users particularly the two-wheeled road users. The Agency has published a separate set of details for this purpose, typical details of some of them can be seen in the picture above.

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