Necessity is mother of invention

Fildrain Geocomposite provides a sustainable alternative to crushed stone

Drainage is a major consideration in all highway and civil engineering projects. For surface water drainage there are many options comprising modern materials and engineers fully utilise these to achieve an optimum design in terms of performance and economy. Equally important is good sub-surface drainage but here (except for carriageway edge drainage), options have been limited to traditional crushed stone filter drains even though modern materials are available. It does seem at times that highway engineering is still in the stone age when it comes to sub-surface and combined sub-surface and surface water drainage(french drains). This article explores the options and attempts to explain the key criteria so that all highway engineers can have the confidence to utilise these new forms of sub-surface drainage in a similar way to the now widely accepted new forms of surface water drainage and new forms of surfacing.

Sustainability

Sustainability is high on the agenda and this increased emphasis leads highway engineers to look again at the tonnage of clean crushed stone consumed in the traditional sub-surface drainage. The modern option of geocomposite drainage enables greater use of site won secondary aggregates and this in turn minimises the number of delivery vehicle journeys. Geocomposite drains are not new - they were invented over 20 years ago - but it has until now, been too easy for engineers to continue to detail the use of traditional crushed stone and largely ignore the geocomposite option. Clients, however, are now asking for their projects to be designed to meet sustainability criteria and the engineers who gain the experience of these modern materials will be the ones who are seen as the champions of sustainability. Geocomposites such as Fildrain from ABG enable significantly reduced volumes of crushed stone, whilst giving enhanced performance at lower cost. If this sounds too good to be true then read on.

Comparison

The importance of achieving good sub-surface drainage to reduce groundwater levels and pore water pressure to increase bearing capacity has long been established. The Romans and McAdam used open ditches which served the combined function of surface and sub-surface drainage. Open ditches progressed to filter stone trenches for traffic safety and ease of

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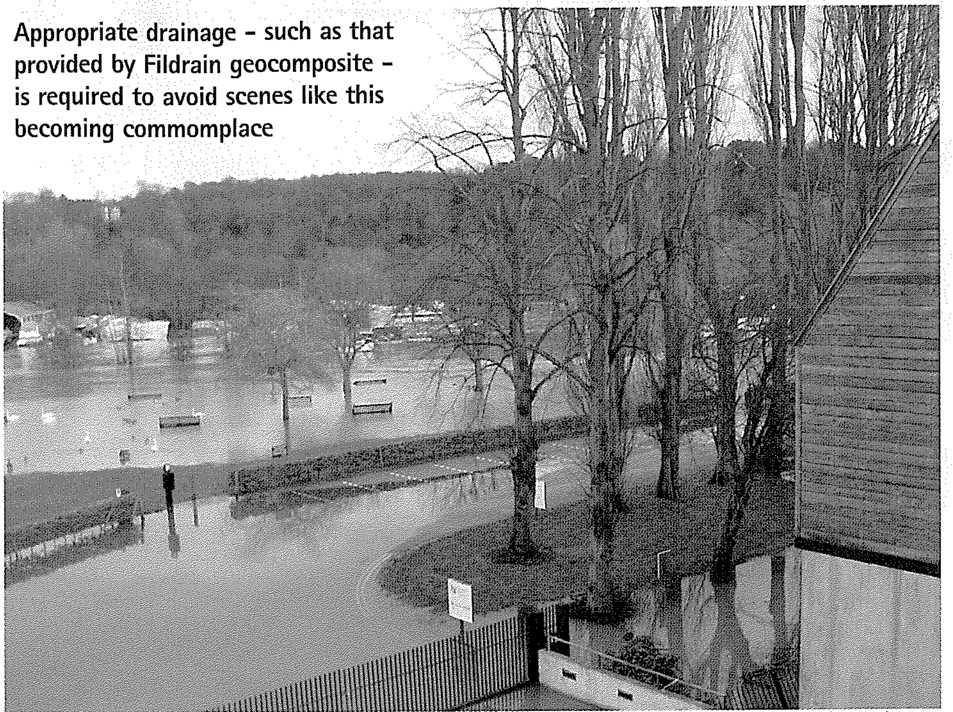
maintenance. Filter stone in the UK is specified to SHW Clause 505 as type A or B and is a graded crushed stone with minimal fines which approximates to a Terzaghi filter. Further progression came with the invention in the 1970's of geotextiles which created the filter around the perimeter of the trench and consequently the trench fill could be a lower cost and higher performance single sized aggregate. This option is now widely used but not all engineers trust the long term performance of geotextiles. There is a lot of mis-understanding of geotextiles and their key criteria, due in part to the wide range of geotextile types available. The geocomposite option reduces this confusion as the manufacturers have used their expertise to select appropriate geotextiles specifically for their drainage performance and these are an integral laminated part of the geocomposite. I will explain later how to guarantee performance from a geotextile but first let me describe this modern development of sub-surface drainage in more detail. The realisation that the geotextile is creating the filter and the stone fill is simply a permeable packing to fill the trench led directly to the development in the 1980's of polymer void formers with sufficient flow capacity and compressive strength to replace the crushed stone and support the geotextile. These geocomposites formed from polymer cores bonded to the geotextile wrap are extremely thin and so the trench can be excavated much narrower and backfilled with the excavated material or low grade material. Crushed stone is only required as pipe bedding and as a 300mm deep collection/filter zone at the top of the trench if the drain is also intended to collect surface water. The reduction in stone volume that results is obvious and the ability to construct narrower trenches leads to further benefits that I shall describe later but first let me explain how a thin polymer core can equate in performance to a 500mm or even 1000mm width of filter stone.

In a traditional stone filter drain the crushed stone allows water to enter over a large surface area and transmits this down to a porous or perforated pipe at the base, this pipe then carries the longitudinal flow. The water obviously cannot flow down through the actual stone particles but follows the voids between the stone particles. These flow paths are very restricted and contorted so the water travels slowly as it weaves its way down between the stone particles. In fact the stone particles themselves are a hindrance and take up most of the volume. The typical specified permeability of crushed drainage stone is 1 x 10-3 m/s which represents the speed of the water flow down through the stone. Compare this with a Fildrain geocomposite cuspated core that has the same large surface area but the internal flow paths have been aligned and streamlined whilst the volume occupied by the cuspated core itself has been minimised. The water is able to flow down through the cuspated core much more quickly so the polymer core can be much thinner than the crushed stone. The permeability of the Fildrain 7D cuspated core is 0.15 m/s =150 x 10-3 m/s which is 150 times faster than the flow in the crushed stone. Hence the Fildrain 7D geocomposite can be 150 times thinner than the equivalent crushed stone filter because the in-plane flow capacity is so huge. Not all geocomposites, however, have such high in-plane flow capacity under simulated site conditions and it is the cuspated core profile that gives Fildrain its performance.



Appropriate drainage - such as that provided by Fildrain geocomposite - is required to avoid scenes like this becoming commomplace

Long Term Performance

The performance of the geocomposite core is one of the key aspects and the other is the long term performance of the geotextile filter that is laminated to the core. As mentioned earlier, geotextiles have been in widespread use for over 30 years and generally give excellent service but as with all materials, if they are used inappropriately they will fail. Some types of geotextile are more forgiving than others. Geocomposite drains largely use a non-woven geotextile to provide the greatest re-assurance of good long term performance. The manufacturers are able to bring their expertise into the selection and ABG chose to use a non-woven needle punched heat treated geotextile. This type of geotextile has good burst strength, high perpendicular water in-flow, zero breakthrough head and a pore size that is compatible with the majority of the UK soils. The most important thing is to realise that a geotextile will clog in a matter of days if it has to filter surface water directly. A sacrificial filter stone layer must be placed above the geotextile or

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geocomposite to trap the fines before the water passes through the geotextile. All of the rumours and myths that circulate and prevent engineers embracing the use of geocomposites relate to such abuse. So, having established that, how does the geotextile provide long term performance in the ground? Soil comprises a range of particle sizes held together in a structure and the geotextile actually makes the soil become the filter. The non-woven geotextile has a random fibre matrix within which are pores through which water can pass. The pores are 40 to 300 micron (with 90% less than 110 micron) and are such that some fine and medium sized soil particles can be washed through. The larger soil particles cannot pass. Initially, as water moves through the soil towards the geotextile, very close to the geotextile it brings the fine and medium particles through the geotextile to be safety carried away by the high flow velocities in the geocomposite core. The large soil particles are too big for the water to move them and the large particles close to the geotextile cannot pass through as they are larger than the pore size. The result is that within days of installation, over an approx 150mm zone adjacent to the surface of the geotextile, the soil itself becomes a stable filter consisting of graded particles – an ideal Terzaghi filter.

Applications

Having established that a high performance cuspated geocomposite can equate to the performance expected from crushed stone lets consider some of the sub-surface and combined drainage applications that can utilise the geocomposite to gain those sustainability benefits. The reduced tonnage of crushed stone is a direct benefit but it also leads to less site delivery vehicles on local roads and easier logistics on site. One standard 6metre vehicle delivery of Fildrain equates to the elimination of100 vehicle loads of crushed stone and probably 100 vehicles loads of disposal of excavated material.

SHW Clause 514 and Detail F18 Carriageway Edge Drains

This clause and the notes for guidance detail the use of traditional and geocomposite drains at the edge of the carriageway to remove infiltration water from the construction layers to prevent saturation of the highway formation. This is a specific function in which the amount of water to be collected is quite small and consequently the required geocomposite performance is usually not so high. All of the options utilise a pipe for the longitudinal flow except the Type 5 where-in the geocomposite also has to be designed to take the longitudinal flow. Type 10 is a special form for drainage below trapezoidal concrete channels (detail F21). In all cases some properties are standard but the key site specific performance must be designed by the engineer and detailed in an Appendix 5/4 and ABG has examples of suitable appendices.

Combined Surface and Sub-surface Drains (French drains) –verge/embankment/cuttings

There could be as many as four French drains running the length of the highway to collect ground water and surface water from the verges, slopes and landscaped areas. Despite geocomposites being a specified option for highway edge drains, these French drains are invariably specified as and constructed using crushed stone. This is typically 24,000 tonnes of crushed stone that is needlessly used. The geocomposite not only saves the stone but also requires less width so helps to accommodate all the highway features into a reduced land take. The geocomposite performance specification required to fulfil the function of French drains is much higher than that required for a simple highway edge drain and therefore the details in SHW Clause 514 and F18 are not applicable. As demonstrated previously in this article, a cuspated geocomposite such as Fildrain 7DW can provide the required level of performance when used with a 300m topping of crushed stone. Geocomposite are also extremely quick to install.

Ground Water Drains

In a similar way to combined drains, ground water drains are not detailed in the SHW as geocomposites but this does not mean that they cannot be used. The geocomposite will provide all of the benefits outlined above and for ground water, the excavated soil backfill can be taken right to the surface. The in-plane flow capacity required for ground water applications is usually moderate.

Cut-Off Drains

These are a special form of ground water drain intended to intercept the ground water flow and prevent it from passing into another zone. A stone filled trench has a substantial width in which to divert the flow, which makes it more effective than a geocomposite unless the geocomposite has a central impermeable barrier such as the cuspated Fildrain 7DW Cut-Off drain, in which case the geocomposite is the most effective.

Counterfort Drains on Cutting Slopes

Sometimes called herringbone drains, these drains collect seepage from the face of the cutting to prevent destabilisation of the cutting face. Traditionally they take the form of shallow stone filled trenches which are not quick to install. A geocomposite can be used in a radically different way laid in sheet form parallel to the slope and pinned in position over the seepage zone. The geocomposite is then simply covered with topsoil.

Earthworks Temporary Drains

Geocomposite drains are not often suitable for temporary earthworks drainage. At this stage of the works, the soil is frequently disturbed and awash with silt laden surface water. The trenches are relatively short and crushed stone is still the most viable option.

Reinforced Earth Drainage

Reinforced earth is widely used as an economic solution for construction of steep slopes and walls. As with all structures the detail is to provide a drainage layer at the rear to relieve water pressure. This drainage layer is very often specified as crushed stone but a geocomposite is easier to install and will provide an equivalent drainage capacity.

Embankment Starter Layers

A 500mm thick granular stone drainage blanket is often placed onto the prepared formation before construction of the embankment commences. This layer serves two functions, one of which is drainage and the other is protection of the formation for the earthworks machines. A suitable geocomposite will provide the required drainage capacity and secondary

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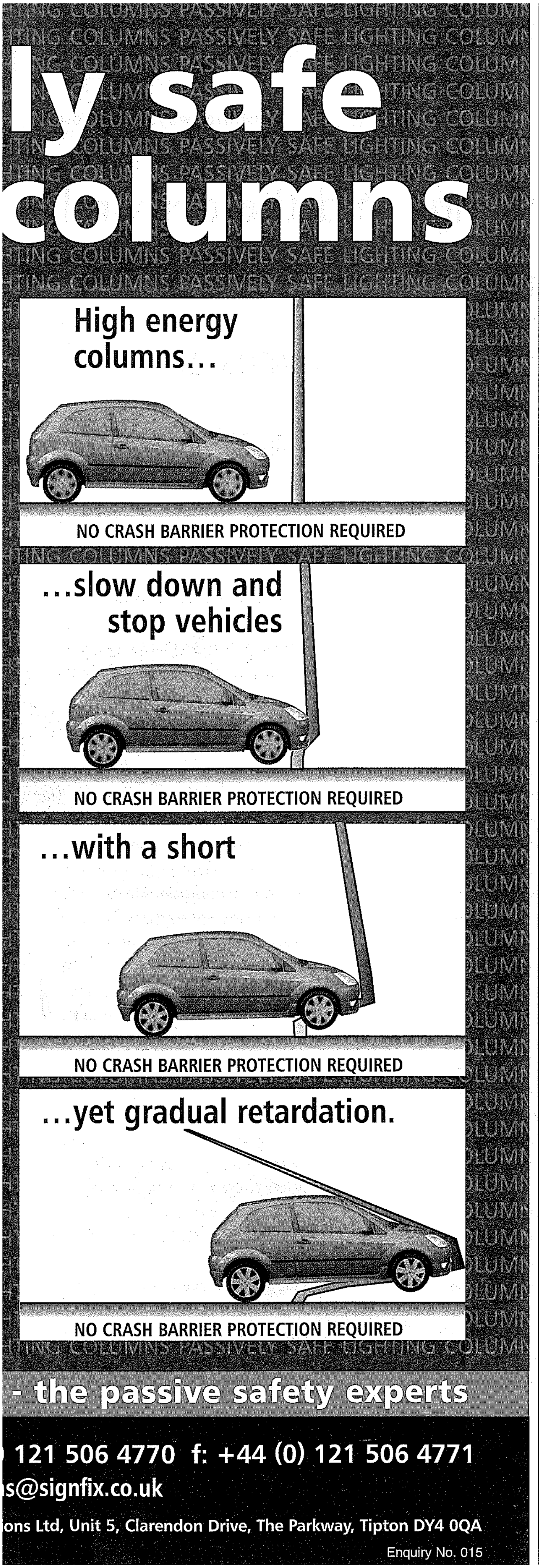

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aggregate should be used for the protection layer if the embankment fill itself cannot be used. The geocomposite should be laid across the width of the embankment and the backfill placed on an advancing face. The geocomposite must have sufficient compressive strength/flow for the forces under the full height of the embankment and ideally have a core with a central barrier that protects the formation from water ingress and re-hydration due to rainfall.

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Embankment Consolidation Layers

Earthworks are usually the critical path in the programming of highway works and soft soil embankments are often a feature of the road alignment and the earthworks balance. The speed of construction of the embankment depends on the rate at which the pore water pressure can dissipate as the embankment height progresses. Conventionally, this limits the choice of fill, restricts progress during the winter and involves several layers of crushed stone to reduce the drainage path. Every layer of crushed stone is less use of fill. Using a geocomposite that is just 7mm thick instead of each 500mm thick layer of crushed stone will save 75,000 tonnes of crushed stone in a typical project. The Fildrain 7DW is produced in 4.4m wide rolls and specifically for this application the double cuspated core profile has central barrier that prevents rainwater from entering the lower layers. Consequently, the speed of consolidation is amazing and this means quicker construction times. On those projects where Fildrain has been used it has been very effective, often enabling the use of material that might otherwise be classed as unsuitable.

What are the key criteria to be considered for a geocomposite drain?

Surface water or purely ground water?
Longitudinal flow taken by a pipe or the geocomposite?
In-plane flow capacity under simulated site conditions at the design compressive confining force.
Geotextile pore size
Geotextile permeability
Geotextile water break through head.
UV exposure limits

Surface water is large in volume and occurs rapidly during rainfall. It also picks up silt and detritus. By comparison, ground water is relatively low in volume, so the first criteria is to establish whether the drainage will take only ground water or an amount of surface water. Because the surface water caries silt, there must be at least 300mm depth of Type A filter stone above the geocomposite and this removes the silt. Just as with traditional crushed stone filter drains, this top layer of stone will need to be maintained periodically. For surface water, the in-plane flow capacity of the geocomposite has to be designed to take a larger volume of water. For ground water drains, the large surface area of the geocomposite is very effective and the excavated material backfill to the geocomposite can be taken all the way to the surface.

The most efficient geocomposite drain usually consists of the vertical geocomposite with a large surface area attached to a longitudinal carrier pipe. This pipe could be porous or perforated or have a sealed invert with a slot into which the geocomposite is inserted. The ABG Fildrain 7DWP or 7DWF takes this form and is used with all sizes of pipe. The geocomposite collects the water, transmits it vertically (hydraulic gradient HG 1) to the pipe and the pipe takes the longitudinal flow. Some cuspated geocomposites such as the Fildrain 25SXW and 50SXW are 25 and 50mm thick and as such they have very high in-plane flow capacity sufficient to also take the longitudinal flow (hydraulic gradient equal to invert gradient) and so remove the need for a pipe.

The in-plane flow capacity of the geocomposite is a key performance criteria and is tested to EN ISO 12958 using SOFT platens to simulate the intrusion of the textile into the polymer core due to soil backfill pressure. Fildrain, with its cuspated core and laminated geotextile configuration achieves minimal loss of performance in such tests. There are also geonet core products and these perform very poorly under SOFT platen simulated site conditions. Consequently, such geonet manufacturers resort to HARD or RIGID platen tests to make the datasheets look good but in reality the flow on site will be lower. Always check that the geocomposite has been tested correctly using SOFT platens at a safe confining pressure similar to the soil pressure at the depth of installation. This would usually be 100 kPa with an FOS of 5.

The geotextile pore size is tested to EN ISO 12956 and expressed as the value of which 90% of the pores are smaller. The pores are small, typically a 90% value of 110 micron (0.11mm) and this is compatible with the majority of UK soils. There are certain problem soils that require a different geotextile with tighter or more

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open geotextile pore size and the pore size can be designed to match the soil grading curve. Some heavily precipitous ground water such as ochra will clog anything including pipes and crushed stone. Geocomposites are no more sensitive to clogging in difficult situations than filter stone and will have the same life expectancy.

The perpendicular flow of water through the surface of the geotextile is measured to EN ISO11058 and the non-woven needle punched geotextile will achieve 90 l/m2/s at 50mm head. This equates to a permeability of 1 x 10-1m/s which is approximately 10,000 times greater than the typical permeability of UK soils. To put this figure in perspective it is best to visualise 90 litres flowing past every second – its a lot and re-assuring to those who fear that geotextiles clog, that the safety factor is so high. A much more significant and often unquoted parameter is the head of water at which water first starts to flow through the geotextile. For some forms of geotextile this could be as high as 100mm in the laboratory tests whereas for a non-woven needle punched heat treated geotextile the value is 0mm indicating that water flows straight away. It is important to have a geotextile with a zero breakthrough head in shallow drainage applications where the capillary suction in the soil will effectively increase the 100mm laboratory test value to a 250mm head before water starts to flow and this can cause clogging in these situations.

Geotextiles are primarily manufactured from polypropylene fibre which has UV inhibitors added during the melt to enable the geotextile to resist a reasonable length of exposure to sunlight during installation. Typically, the geocomposite should be installed and backfilled within 14 days to ensure no measurable loss of performance. Polypropylene geotextiles and polyethylene geocomposite cores have excellent chemical resistance.

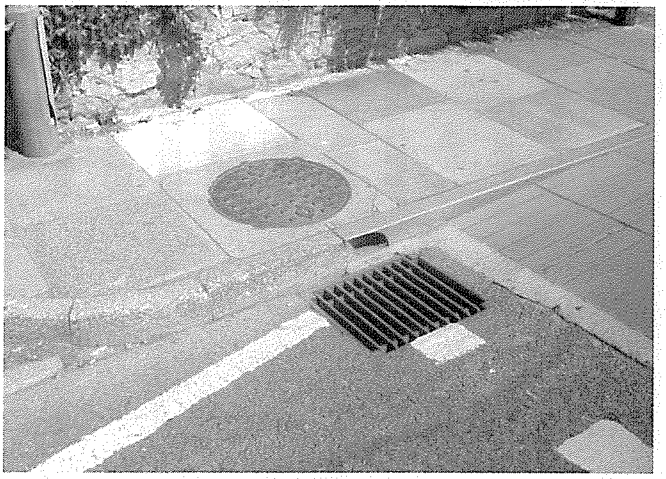
Simple Design

These considerations might at first appear to be daunting compared to the simplicity of using standard specifications for crushed stone but it really is not that complicated. The major UK manufacturers such as ABG run training courses or in-house CPD that explain the design process. Indeed, the geocomposite does not have to be designed in every instance. The high performance cuspated geocomposites in the Fildrain range have drainage performance far in excess of anything stone drains can achieve and yet will still provide a realistic cost saving. If the engineer knows the basics then it is possible to safely select a standard geocomposite solution in a similar way to selecting crushed stone.

Conclusion

It is the client and contractor who gain the real benefits of geocomposite drainage but it is the design engineer that has to develop new and initially time consuming procedures. As with any change to existing practise, there are new things to learn whereas existing crushed stone drainage is already detailed in standard drawings and requires no thought other than to determine the pipe size. Some engineers, however, are pioneers and they move the industry forward and set the new standards for others to follow. Climate change and the demand for sustainable solutions are at last driving old practices to change and new ideas to be embraced. Virtually every application that currently uses drainage stone can be replaced by a geocomposite. Geocomposite drainage is a sustainable solution produced either from virgin or recycled polymer and engineers should consider that every tonne of crushed drainage stone they detail is effectively a wasted resource.

PONDING PREVENTED



The Kinghurst bypass kerb maintains channel continuity when kerb to kerb road humps and speed tables are built.

The kerb is removed next to the hump and the unit installed. Anchor brackets under the unit are cast into a bed of concrete laid in the void created by removing the kerb.

Water enters the unit through a hole in the side wall, runs along inside the unit in the line of the kerb before being returned to the channel through a second opening once the obstruction has been passed.

For more information please contact:

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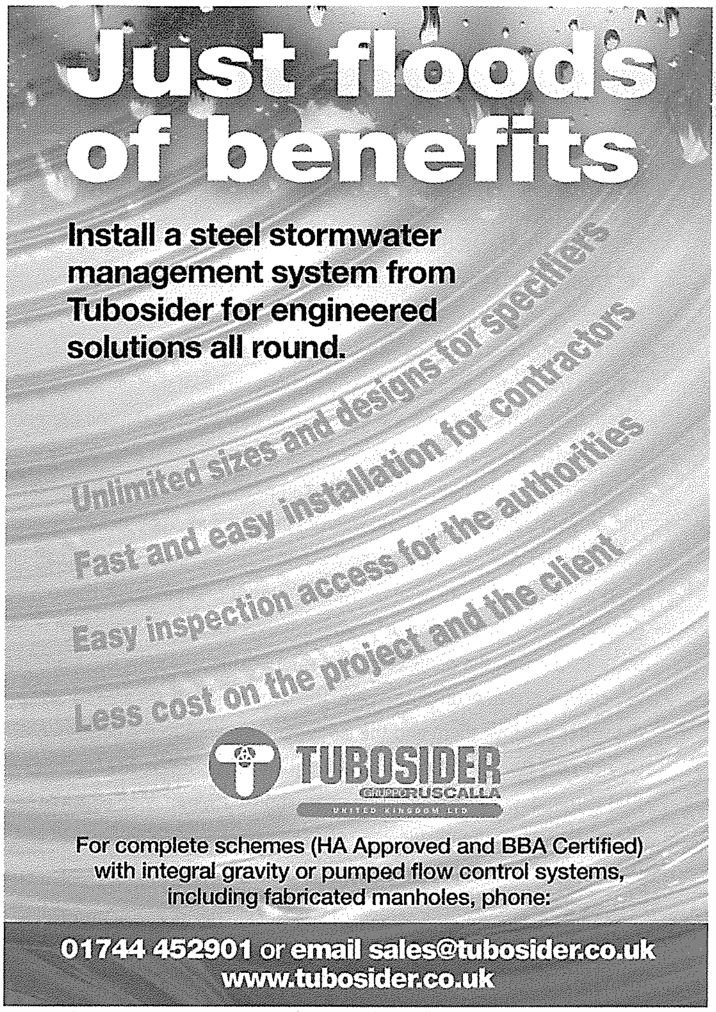

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