VOLUME 4 GEOTECHNICS AND DRAINAGE

SECTION 2 DRAINAGE

PART 4

HA 217/08

ALTERNATIVE FILTER MEDIA AND SURFACE STABILISATION TECHNIQUES FOR COMBINED SURFACE AND SUB-SURFACE DRAINS

SUMMARY

This Advice Note gives guidance on the design, construction and maintenance of combined surface and sub-surface drains (also called French Drains), where used as a road drainage system. This also covers the use of topping materials as a safety feature and considers the use of alternative filter materials and the maintenance and rehabilitation of the drain.

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Volume 4, Section 2,
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Alternative Filter Media and Surface Stabilisation Techniques for Combined Surface and Sub-surface Drains

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Contents

1. INTRODUCTION

General

1.1 This Advice Note gives guidance on the design, construction and maintenance of combined surface and sub-surface drains (also called French drains), where used as a road drainage system. In most of the UK the term 'highways' is equivalent to Scotland and Northern Ireland's 'roads'. In this document, as with the guidance provided in HA 216 (DMRB 11.3.10), the term 'roads' will be used as standard terminology. Although the advice should be fully taken into account in the design of new schemes (see 1.7), this Advice Note contains no mandatory requirements.

1.2 The safety aspects of drainage features are described in HA 83, *Safety Aspects of Road Edge Drainage Features* (DMRB 4.2). Further details, including safety aspects of combined surface and sub-surface drains topped with bitumen bound shredded tyre material are given in TRL Report 422 (Ref 3).

1.3 The potential for a drainage element to become a safety hazard is generally a function of its location. The purpose of a combined surface and sub-surface drain is to remove water from the road surface and its foundation layers and to provide a degree of filtration and flow attenuation. It is most effectively located at the nearside carriageway edge or in the central reserve. As a consequence, these drains may be vulnerable to vehicle over-run that may dislodge the filter medium and the resulting stone scatter on the carriageway can present a hazard to road users and vehicles.

1.4 Although once widely used, this drainage system has been discouraged for the reasons above. The development of a number of techniques, described in this Advice Note, that may be used to stabilise the material or replace the material in the top layer of the drain now allow the system to be utilised with greater confidence.

1.5 This Advice Note covers the use of topping materials as a safety feature and considers the use of alternative filter materials and the maintenance and rehabilitation of the drain. (Ref 4)

Environmental Aspects

1.6 The environmental and pollution control benefits of filter drains stated in HD 33, *Surface and Sub-surface Drainage Systems for Highways* (DMRB 4.2) are the effective adsorption of suspended solids and heavy hydrocarbons. They also provide a degree of flow attenuation. These factors should be material considerations when undertaking any need for mitigation as identified through the assessment process in HA 216 (DMRB 11.3.10). They could be an effective form of primary treatment.

Scope

1.7 The principles outlined in this Advice Note apply to all schemes on trunk roads including motorways. They may also be applied generally to other new road schemes and by other road authorities for use during the preparation, design and construction of their own comparable schemes. Surface toppings or stabilisation may be installed during major maintenance works or as a retro-fit for areas where stone scatter has been identified as a major safety issue.

Implementation

1.8 This Advice Note should be used forthwith for all schemes currently being prepared provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay progress. (in either case the decision must be recorded in accordance with the procedure required by the Overseeing Organisation). Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

2. PRINCIPLES

Function

2.1 Combined surface and sub-surface drains in new road construction have been used less in recent years as they were once considered undesirable for use as carriageway surface drainage system. However, they are still permitted in certain circumstances, as shown on drawings B1 and B5 of the HCD (MCHW 3) and substantial lengths of these drains still remain in service on the network.

2.2 The function of the combined surface and sub-surface drain is to drain water from the carriageway surface, to remove sub-surface water from the unbound pavement layers and prevent ground water entering the pavement foundation.

Design

2.3 The combined surface and sub-surface drain comprises a carrier pipe that is either perforated, porous or open jointed, bedded in granular material, in a trench that is then backfilled with a granular filter material of Type A, B or C (see Detail F2 of the HCD (MCHW 3)). The type of filter material is classified by the grading, tabulated in Table 5/5 of the SHW (MCHW 1).

2.4 The carrier pipe for the combined surface and sub-surface drain should be designed in accordance with HD 33 (DMRB 4.2). Note: HD 33 requires the pipeline to have sufficient capacity such that there is no surcharge of the pipe on a 1 in 1 year basis (100% annual risk) and no flooding during a 1 in 5 year rainfall event (20% annual risk). Designers should be aware that exfiltration from a porous or perforated pipe can occur before the pipe becomes surcharged. For this reason the designer may wish to consider increasing the pipe diameter to the next available diameter (e.g. increasing the diameter to the next larger size, say from 225mm to 300mm, increasing the pipe capacity by around 100%) reducing the depth of flow in the pipe. The designer should check the part full flow characteristics of the proposed pipe to ensure self cleansing velocities are maintained (Ref HD 33).

2.5 A significant proportion of the combined surface and sub-surface drains in service have been constructed with a non-standard geotextile wrap to either the entire drain, including the pipe and bedding, or to the filter medium. The purpose of the geotextile is to prevent fine particles being washed into the drain from either the unbound pavement layers or the trench side. In either case, the pores of the geotextile can become clogged with fine particles and hence render the drain unserviceable. Where the use of a geotextile is considered appropriate the pore size should be selected using the same criteria as used for fin drains given in NG 514 (MCHW 2).

2.6 The presence of the geotextile fabric, especially where wrapped over the drain, can also hinder the temporary removal of the filter material during on-site cleaning; see Chapter 7, when the fabric must be removed from the excavation.

2.7 The potential for stone scatter from combined surface and sub-surface drains is often greatest where:

- slip roads join the main carriageway;
- drains located in the central reserve at the pavement edge in front of the safety barrier;
- the drain is located on a bend;
- drains are adjacent to lay-bys, service areas or grade separated junctions of two or more primary routes, where drivers of goods vehicles may pull off from the paved surface.

2.8 For new build sites, risk assessment at the design stage can eliminate the potential for stone scatter.

3. STABILISATION

General

3.1 The location of combined surface and sub-surface drains, immediately adjacent to the hard strip or hard shoulder, means that they are liable to be over run. The use of the hard shoulder as a running lane during planned maintenance operations may place fast moving traffic close to the combined surface and sub-surface drain.

3.2 Where rounded filter medium has been used, heavy vehicles in particular can become stranded as the filter medium is displaced by the wheels allowing the vehicle to sink into drain. Extraction of heavy goods vehicles can be difficult causing disruption and delay to other road users.

3.3 Stabilisation of the drain surface can significantly reduce the risk of occurrence of both stone scatter and stranded vehicles.

Geo-synthetic grid for surface stabilisation of combined surface and sub-surface drains

3.4 Clause 4.14 of HD 33 (DMRB 4.2) permits the incorporation of a geo-synthetic grid into the surface layer of the filter material as a means of reducing the risk of stone scatter. This process locks the aggregate particles together forming a stable surface that enables fully loaded heavy goods vehicles (HGVs) to be driven into and out of the drain, reducing the risk of the wheels sinking into the drain and the vehicle becoming stranded TRL Report UPR/IE/181/06 (Ref 4).

3.5 Trials reported by Watts and Todd (Ref 4) have shown that suitable geo-synthetic grids should be of a high density polyethylene or polypropylene, have a nominal ultimate tensile strength in each direction of 30kNm and have a minimum aperture of each grid similar to the maximum aggregate size, around 60mm.

3.6 Before placing the reinforcement, the filter material should be excavated to a depth greater than required for the geo-synthetic grid, and the surface compacted with one pass of a vibrating plate compactor. Note: - over compaction may crush the material resulting in small pieces of aggregate and a consequent reduction in the effectiveness of the reinforcement. A thin layer of aggregate should be spread over the compacted surface to provide interlock and the geo-synthetic grid placed over this.

3.7 The geo-synthetic grid should be placed flat over the full width of the drain and be between 100mm and 150mm below the surface of the combined surface and sub-surface drain. Trials have shown that there is no benefit gained by turning the geo-synthetic grid upwards at the drain edges.

3.8 The minimum overlap at joints in the geo-synthetic grid reinforcement should be 300mm.

3.9 Following filling, the final surface of the drain should be compacted by a further pass of a vibrating plate compactor to lock the aggregate and reinforcement.

3.10 Geosynthetic grid can be repaired by cutting out damaged sections and inserting and overlapping new material as specified above.

Surface treatments for surface stabilisation of combined surface and sub-surface drains

3.11 Surface treatments to combined surface and sub-surface drains should be considered where stone scatter has been identified as a potential problem as defined in paragraph 2.7.

3.12 Surface treatment may also provide an opportunity for increasing the attenuation of peak surface water run-off flows, the degree of treatment or, the containment of road-generated contaminants.

3.13 Chapter 4 contains further guidance on the following methods of surface treatment:

- topping with bitumen bound shredded tyres;
- grassed surface;
- semi-paved surface.

3.14 Composite construction, combining the benefits of both the combined surface and sub-surface drain and a grassed channel are discussed further in Chapter 5.

4. SURFACE TREATMENTS

BITUMEN BOUND SHREDDED TYRES

General

4.1 Bitumen bound shredded tyre material should only be used as a topping to improve safety; it should not be used as an alternative filter material. To avoid any possible contamination of groundwater or controlled waters, total immersion of the bitumen bound material should be avoided. The material should be confined to the drain surface, with a maximum thickness of 200mm, ensuring that the material remains well clear of any water table (Ref 5, 6 and 7).

4.2 Monitoring of water samples obtained from both bitumen bound shredded tyre and conventional stone topped combined surface and sub-surface drains have shown that there is no significant difference in the run off quality (Ref 6).

4.3 Tyres used in the process should be those from either heavy goods vehicles or earth moving vehicles as these tyres contain a small amount of steel and have a thick tyre wall that can produce suitable rubber chunks when shredded. Car tyres should not be used as these contain a comparatively large volume of steel and thin walls. Shredding car tyres can result in large areas of exposed steel braid with sharp edges that pose a health and safety hazard to road workers. Car tyres have very poor permeability characteristics when bonded due to their thin walls.

4.4 Monitoring trial sections of bitumen bound shredded tyre topping showed that the new material can be expected to have a permeability of between 1.0 and 1.5 m/s (Ref 6). By comparison, the values for conventional stone filled drains are between 2.5 and 3.5 m/s. (Refs 6 and 8).

4.5 Where vehicles over-run on to conventional stone filled combined surface and sub-surface drains, instability of the surface may occur from braking or sliding on the loose stones. The bitumen bound tyre surface is sufficiently cohesive to be able to withstand these effects with little loss of tyre material. Trials have shown that dislodged rubber pieces do not pose a significant risk of damage to other vehicles.

4.6 The risk of fire posed by the use of bitumen bound shredded tyres is low despite the material being readily ignitable. Under trial conditions, it can take some 20 minutes before a fire becomes established; even then the progress of the fire is slow (although dense black smoke given off by the material may pose a visibility hazard). As part of the combustion process, small carbon particles are formed which have the effect of filling the voids in the material, thus cutting off the air supply to the fire. Experiments have shown that in the event of fire, damage is likely to be confined to the upper 50mm of the topping (Ref 6 and 9).

Preparation

4.7 The optimum thickness for bitumen bound shredded tyres surfacing for a combined surface and sub-surface drain is between 150mm and 200mm. Prior to the placement of the tyre material, in the combined surface and sub-surface drain and carriageway pavement, the locations of Motorway Incident Detection and Automatic Signalling (MIDAS) detector loops and other similar equipment should be identified.

4.8 The existing stone filter material should be excavated to a depth that will provide the design thickness of bitumen bound shredded tyres. Care should be taken to ensure that the final surface of the bitumen bound tyre material is at or lower than the carriageway edge level by 0 to 25mm. See Drawing B15 in the HCD (MCHW 3) where the detail for sub-base surface is comparable.

4.9 Where a soil strip exists between the carriageway edge and the drain, this may support vegetation growth that will eventually restrict surface water flows to the drain. Therefore the soil strip should be excavated to the same depth as the filter material and replaced with bitumen bound tyre surfacing.

4.10 At some sites, the binder-course and roadbase may extend beyond the surface course at the pavement edge. The thickness of the surface course is similar to the diameter of the larger pieces of shredded tyre and hence any surfacing laid over the binder-course, at the pavement edge, will be thin. Consequently, this may make the bitumen bound shredded tyre surface prone to breaking up due to vehicle over running. In this situation, it is recommended that the edge of the pavement should be saw cut to roadbase depth. This will provide a neat edge finish and increase the thickness of bitumen bound shredded tyre material immediately

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adjacent to the pavement construction, forming a stronger surfacing layer.

4.11 Where a combined surface and sub-surface drain is in a position remote from the pavement edge, such as in the central reserve, where it may abut a verge or paved surface, the adjacent surface may be cut back to prevent material breaking away from the trench side and contaminating the filter material or fractures forming in the paved surface. Timber formwork may be erected in the excavation and the bitumen bound tyre surfacing placed up to this, forming a neat edge finish with a constant thickness of material. On removal of the formwork the verge or paved central reserve should be reinstated.

Installation

4.12 The shredded tyre material to be used in the surfacing should be supplied to a grading comparable to that of Type B, shown in Table 5/5 of the SHW (MCHW 1). Guidance on the installation of this material is contained in Appendix A.

4.13 Coloured emulsion may be applied to the finished surface to differentiate between the carriageway and the drain surfaces. Red can act as a visual warning while beige gives a natural stone effect. Alternative colour finishes may be applied subject to the agreement of the Overseeing Organisation.

4.14 As discussed in 4.3, the permeability of bitumen bound shredded tyre topping is lower than for conventional filter material. Clause 8.5 of HA 83 (DMRB 4.2.) draws the designers attention to the need to dish the surface of the capped combined surface and sub-surface drain. This feature may be incorporated into the bitumen bound shredded tyre surfacing as a means of diverting high flows to outlet gratings without hazard to road users. The slope of any channel should not be steeper than 1 in 5.

4.15 Experience has shown that bitumen bound shredded tyre surface material tends to become clogged along the edge adjacent to the pavement. An alternative arrangement is to form a crossfall over the surfacing sloping away from the pavement edge, surface water will naturally flow towards the rear of the drain. This will reduce the risk of ponding.

4.16 Where bitumen bound topping material is used next to grated catchpits or chambers, pieces of shredded tyre can become detached from the matrix.

4.17 The Design Organisation should consider what special precautions, if any, should be taken to ensure that pieces of the topping material do not enter the drainage system through any gratings or other openings.

4.18 Bitumen bound shredded tyre material produces a stiff matrix that should be capable of supporting pedestrians and cyclists. However, the shredded tyre used in the process does contain a small amount of steel. The Design Organisation should consider whether any exposed steel may present a potential hazard to cyclists and pedestrians.

GRASSED SURFACE

General

4.19 A derivative of the grass surface detail combining the filtration properties of the combined surface and sub-surface drain with hydraulic properties of the Grassed Surface Water Channel (HA 119, *Grassed Surface Water Channels for Highway Runoff* DMRB 4.2.) is described in Chapter 5 Composite Construction.

4.20 The typical detail for constructing a grassed surface to a combined surface and sub-surface drain is shown in drawing B15 Type V in the HCD (MCHW 3).

4.21 The detail comprises a geotextile fabric blanket placed over the filter medium beneath 150mm of topsoil. A geotextile filter material is recommended to minimise contamination of the filter medium by topsoil. The filter should be a non-woven geotextile selected in accordance with the criteria used for fin drains given in NG 514 (MCHW 2).

4.22 Greater stabilisation of the combined surface and sub-surface drain is achieved by the insertion of geo-synthetic grid into the top 150mm of the filter medium, see Chapter 3 Stabilisation.

SEMI PAVED SURFACE

Bitumen bound Aggregate Topping for Combined Surface and Sub-surface Drains

4.23 This applies only to the top 200mm of combined surface and sub-surface drains. The material may be applied either to complete the backfilling of a new combined surface and sub-surface drain or to an existing drain after prior removal of the uppermost 200mm of existing material.

4.24 Refer to Appendix A for the installation specification.

Porous asphalt

4.25 The cost of the materials has lead to a rapid decline in the use of this material as a carriageway surface course.

4.26 Its use as a topping to combined surface and sub-surface drains, independent of the pavement surfacing has been considered in terms of construction (Ref 10), recommending minimal compaction as a means of maximising the relative hydraulic conductivity.

4.27 The recommended compaction is one pass of a hand held mechanical compactor, (1260 kg/m^2).

4.28 Laboratory and monitoring trials have shown that the relative hydraulic conductivity decreases as the material ages and becomes clogged with sediment and vehicle-generated greases. The relative hydraulic conductivity is also affected by topography, areas of porous asphalt at the lower end of a longitudinal gradient were observed to clog at a faster rate than those towards the top.

4.29 Porous Asphalt is not an ideal solution but can be useful where vehicles have to pull off the carriageway, such as at maintenance areas or for patrol vehicle standings.

Other surfacing

4.30 Type 1 (Type 3 in NI) sub-base has been used occasionally as a surface to combined surface and sub-surface drains, refer to Detail B15 of the HCD (MCHW 3). Type 1 sub-base material has a low hydraulic conductivity and while sealing the surface of the drain, is unlikely to facilitate the ingress of surface run-off.

4.31 It has been previously used as a surfacing to combined surface and sub-surface drains in the central reserve, where stone scatter and over-run could have safety implications for fast moving vehicles.

5. COMPOSITE CONSTRUCTION

General

5.1 Composite construction combines a combined surface and sub-surface drain with a grassed surface water channel (Refer to HA 119, *Grassed Surface Water Channels for Highway Runoff* (DMRB 4.2) similar to that for a grassed surface shown as Type V in the HCD (MCHW 3) drawing B15 but with an amended topsoil depth (see paragraph 5.5). Sub-surface and low water flows are drained by the combined surface and sub surface element, high water flow rates pass directly to the grated inlets via the grassed channel.

5.2 The construction of the grassed surface water channel could be used as a treatment to existing combined surface and sub-surface drains ideally following cleaning of the in-situ filter material. The application of this solution may be particularly appropriate in rural locations for the following reasons:

- economic solution;
- elimination of stone scatter, improving safety;
- provides flow attenuation;
- treatment of runoff water improving water quality, and
- aesthetically pleasing, as a green solution.

5.3 Grassed surface water channels are an alternative to the use of slip formed concrete channels, and offer a number of benefits, refer to Advice Note HA 119, *Grassed Surface Water Channels for Highway Runoff* (DMRB 4.2).

5.4 The potential benefits of a composite construction are:

(a) The initial run off that occurs as the rate of surface water runoff is increasing contains a higher level of contaminants, the so called ‘first flush’. At the lower flow rates, the runoff will soak through the channel invert and enter the combined surface and sub-surface drain affording a degree of pollutant removal.

(b) As the flow rate increases, the grassed channel can deliver the peak surface water discharge directly to grated inlet covers at the chambers, but in so doing, provide an element of attenuation and treatment due to the comparative low flow velocities in grass channels.

(c) Sediment will be retained within the grass channel fabric and consequently should reduce the frequency that filter material requires cleaning.

(d) The presence of the channel minimises the risk of a vehicle disturbing the filter material and scattering stone on to the carriageway surface.

Construction detail

5.5 To achieve the desired profile, approximately 400mm depth of medium should be removed from the drain. A non-woven geotextile should be positioned over the exposed medium. Graded subsoil, in compliance with a Class 4 material as defined in the Table 6/1 of the SHW (MCHW 1), should be placed and compacted to form a V channel profile. Advice on suitable soils and their placement is given in HA 56, *The Good Roads Guide: New Roads Planting, Vegetation and Soils* (DMRB 10.1.2,). The subsoil should be non cohesive and fairly permeable, having permeability in excess of 10-4m/s, after compaction, to ensure that the grass roots get air as well as water. Some 35mm to 50mm of topsoil should then be placed such that the maximum depth to the channel invert is 200mm.

5.6 Hydro-seeding is the recommended method of grass establishment, although turfing is a suitable alternative. Guidance on appropriate grass seed mixes is contained in HA 119, *Grassed Surface Water Channels for Highway Runoff* (DMR B4.2).

5.7 HA 119 (DMRB 4.2) recommends forming a cellular block surround to chamber gratings associated with outlets from grassed channels. Consideration should be given to locally reinforcing the grassed surface in similar locations. Pull off areas for maintenance vehicles can be constructed in the same manner.

6. ALTERNATIVE FILTER MEDIA

Use of Recycled Aggregates

6.1 Clause 505 of the SHW (MCHW 1) requires recycled coarse aggregate or recycled concrete aggregate to be tested in accordance with Clause 710 (MCHW 1) and to comply with the requirements of Table 8/3 (MCHW 1 800 Series).

6.2 Clause 710 and Table 8/3 relate to aggregates used in bound pavement construction rather than filter material.

6.3 Further guidance on the suitability of secondary and recycled materials for use as a drainage material is contained in HD 35, *Conservation and the Use of Secondary and Recycled Materials* (DMRB 7.1.2)

6.4 Where filter material is used within 500mm of concrete, bound materials, other cementitious materials or stabilised capping forming part of the permanent works, or within 500mm of any metallic items forming part of the permanent works then the relevant conditions stated in clause 503 of the SHW apply.

Crushing strength

6.5 Recycled aggregates should attain a CBR value greater than or equal to 15 per cent.

Grading

6.6 All recycled aggregate shall comply with the appropriate grading in Table 5/5 of SHW (MCHW 1). Although Type A material has been shown to perform satisfactorily, Type B medium has a much greater permeability and is therefore more effective.

Crushed concrete

6.7 Re-cycled aggregates derived from crushed concrete are readily available and widely used in the construction industry for a variety uses. Levels of impurity in concrete from a purpose built recycling plant are acceptable for most unbound applications. However, due to the use of recycled aggregates in modern concrete, future environmental requirements may apply constraints on the use of this material. For further guidance, refer to the Overseeing Organisation.

6.8 Calcium and some sulphur compounds may leach from the surface of the particles but there is no migration of these contaminants from the interior.

6.9 Contamination by calcium compounds can lead to very high Ph levels. The alkalinity of crushed concrete can have a significant impact on a receiving watercourse, particularly when the water in the stream is soft, i.e. has a low calcium content. Crushed concrete aggregate should be well weathered and/or have been repeatedly washed until a pH <8 is achieved (see paragraph 6.16).

Unbound tyre chips

6.10 The material should be similar to that used as the raw material for bitumen bound shredded tyre topping and comprise chips or shreds obtained from earth moving or heavy goods vehicle tyres with a minimal amount of steel bracing.

6.11 The tyre chips should be cleanly cut so that no exposed steel protrudes from the chip as stated in 4.3.

6.12 Tyre chips are a relatively compressible material. Tests on tyre shreds less than 75 mm in size show that vertical strains of up to approximately 25% may occur in the tyre shreds under low vertical stresses up to approximately 48 kPa (Ref 11) and that vertical strains of up to approximately 50% may occur under high vertical stresses up to 483 kPa.

Glass

6.13 Recycled glass is commonly available as glass sand. Crushed, washed glass is also available and can be graded to form a filter material. Due to its nature, large pieces of glass are undesirable as a filter medium, so for it to be acceptable there will have to be a compromise on the grading: a glass sand of comparable grading to that of Type A may be more appropriate.

6.14 Trials have shown that Type A graded filter material does not infiltrate the perforations of a carrier pipe in any significant quantity, however the permeability of this material, although still good, is significantly less that that of a crushed stone graded to Type B.

Granular Blast Furnace Slag

6.15 Modern slags are principally sourced from steel plants and are widely used as aggregates in the construction industry, particularly for road construction.

6.16 It is important that material selected for use as filter material has been allowed to weather prior to placement, as potentially leachable calcium and sulphur compounds present in slag can be managed by appropriate material selection and weathering of the slag. To this end, specific guidelines have been issued by the Environment Agency and the Quarry Products Association (Ref 12) to avoid the harmful leaching of sulphur. The guidelines state that unbound blast furnace slag should not be used below the water table or in waterlogged areas. In practice, sulphur is leached from the surface of the particles and there is no migration of sulphur compounds from their interior. Thus after the initial dissolution the concentration of sulphur rapidly decreases and will only increases again if the slag particles are crushed and new surfaces exposed.

6.17 There is very little evidence of slags causing groundwater pollution when correctly specified and placed (Ref 12). However, a review of the leaching behaviour of a range of materials was reported by CIRIA (Ref 13), ranked the materials based on their potential to contaminate groundwater and classified with respect to drinking water standards. Blast furnace slag is classified as Category 1 for unrestricted usage (equivalent to limestone).

6.18 Traces of mercury can leach from blast furnace slag, consequently this material is neither suitable for use in the vicinity of an aquifer nor permanent immersion in groundwater. Should blast furnace slag be considered for use in combined surface and sub-surface drains, then advice should be sought from the Overseeing Organisation.

7. MAINTENANCE

General

7.1 Maintenance issues include the removal of sediment, intrusion by vegetation and damage by vehicular over run.

7.2 Sediment accumulation is a problem that affects both the surface and the sub-surface parts of the combined surface and sub-surface drain. Fine sediment is deposited on the filter material at lower levels of the drain, whereas the more coarse sediment and debris accumulate towards the surface, reducing the permeability of the medium and consequently the finer particles are also deposited closer to the surface. The presence of sediment tends to sustain vegetation growth which traps more sediment and ultimately compromises the function of the drain.

7.3 The rate of sediment accumulation is dependent on factors such as carriageway geometry, e.g. drains located towards the lower end of an incline, or on a steep slip road, experience more rapid sediment accumulation than those adjacent to a level carriageway. Adjacent land use may affect the rate of sediment accumulation, e.g. arable farming can generate wind blown sediment.

7.4 Pollutants tend to bind to the finer sediment particles washed from the pavement surface. Pollutants can leach from the sediment retained within the filter medium and consequently the filter material should be rehabilitated once sediment accumulation is observed on the surface in order to maximise the removal of pollutants.

7.5 There is no specified frequency for sediment removal from combined surface and sub-surface drains other than as required by the Overseeing Organisations.

7.6 The impaired function of the drain can be improved by the removal of sediment from the filter material. This can be achieved by either:

- excavation and disposal to a suitably licensed facility and replacement with fresh aggregate; or
- the excavated material can be cleaned at the point of excavation using suitable closed cycle washing equipment and returned to the drain.

7.7 There are several proprietary processes for achieving on site cleaning and replacement of combined surface and sub-surface drain aggregate.

7.8 These involve excavating the aggregate, passing the material through the cleaning apparatus and returning the aggregate directly to the drain trench. Excavation inevitably results in the removal of some materials from the trench sides and consequently there will be a loss of material that can either be replaced with fresh aggregate or recycled materials, see Chapter 6. Any waste arising as a result of these operations should be disposed of in accordance with HA 103.

Stone Filter Medium

7.9 The filter aggregate is valuable resource, and replacement with new quarried stone, while disposing of the contaminated material to landfill, is poor environmental practice in terms of vehicle movements, intrusion of quarries and use of landfill sites.

7.10 All methods of cleaning the stone involve excavating the stone from the drain, treating it and returning it to the drain trench. Cleaning on site offers the benefits of minimising the volume of quarried stone and the numbers of vehicles within the working area.

7.11 The depth of contaminated filter material to be removed can be established by excavating trial holes in advance of the works.

7.12 To be thoroughly cleaned, the stone may be pressure washed or tumbled through a series of drums to loosen the sediment or a combination of both.

7.13 When aggregate is removed for cleaning, it may be appropriate to install a reinforcement system to reduce the stone scatter and vehicle founding risks, as detailed in Chapter 3 Stabilisation.

Bitumen Bound Shredded Tyre Surfacing

7.14 The bitumen bound shredded tyre surfacing to combined surface and sub-surface drains is quite stiff and hence any sediment that may form a surface crust is not readily broken up.

7.15 Research has shown that the permeability of this surfacing may be improved by pressure jetting to clear silt from the surface (Ref 6). Care should be taken to ensure that the water pressure does not damage the surface or that the silt is not forced further into the surfacing. A suitable method has proved to be use of a vacuum road sweeper equipped with water jetting nozzles. Trials (Ref 14) showed that with repeated passes, the sweeper equipped with water jets restored the permeability of the surfacing to almost the initial value.

7.16 Observations show that, provided any soil strip between the carriageway and drain has been removed, any vegetation that does grow on the tyre material is unlikely to become established. The temperatures generated in the bitumen bound shredded tyre topping when exposed to strong sunlight are sufficient to kill any vegetation that may have started to grow (Ref 15). Treatment using herbicides is unlikely to be required.

7.17 Where the surfacing material has been displaced as a whole, e.g. by repeated vehicular over run, the damaged section will have to be removed and replaced as detailed in Chapter 4.

7.18 Where loose pieces of the material are present on the surfacing but the surfacing as a whole remains in place, trials have shown that the loose tyre shreds adjacent to the carriageway are unlikely to pose a significant risk of damage to vehicles or of injury to persons.

7.19 A method of reforming the bitumen bound shredded tyre topping material in situ has yet to be developed.

7.20 The topping material can be removed with an excavator. By saw cutting into manageable sections, the material can be pulled clear of the stone filter material for removal from site to tip by lorry.

7.21 Disposal of the arisings will have to comply with relevant legislative requirements.

7.22 After the removal of any topping material which needs to be replaced, the procedures in Chapters 3 and 4 may be used to construct a new topping to the drain.

7.23 Bitumen binder can break down over time resulting in a loose unbound material. Loose material may be re-bound using an emulsion sprayed over the surface. Advice on suitable materials should be sought from the Overseeing Organisation.

Grassed Surface/Composite Construction

7.24 The presence of the surfacing material limits the scope for improving the performance of the filter material, however its presence should minimise the volume of coarse sediment that enters the drain.

7.25 Guidance on the maintenance of grassed surfaces is contained in Chapter 12 of HA 119 (DMRB 4.2) and is described in Report SR 662 (Ref 16).

Semi Paved Surface

7.26 The permeability of porous asphalt is reduced by the build up of sediment within the voids of the material. The use of a road sweeping vehicle in conjunction with water under pressure can flush the sediment from these voids which is then vacuumed into the sweeper tank.

Road-side Furniture

7.27 When programming combined surface and sub-surface drain maintenance, the presence of items such as safety fencing and induction loops, should be considered. The presence of the barrier and concrete surround to the posts may prevent mechanised cleaning of the aggregate.

8. SPECIAL CONSIDERATIONS

Reptiles and Amphibians

8.1 The filter medium in combined surface and sub-surface drains tends to remain cool and damp in all weather conditions. This can provide an ideal habitat for reptiles such as lizards, slow worms and amphibians such as newts and frogs.

8.2 Some species are afforded protection in the UK through the Wildlife and Countryside Act 1981 (as amended), and the Wildlife (Northern Ireland) Order 1985 (Ref 17); and the Habitats Directive (Ref 18) implemented in Great Britain by The Conservation (Natural Habitats) Regulations 1994 (as amended) and The Conservation (Natural Habitats & c.) Regulations (Northern Ireland) 1995 (Ref 19). The Act and Directive are implemented through HA 98 (DMRB 10.4.6). In areas where such species are known to occur, the advice given in HA 98 should be followed.

8.3 Should a protected species be found, the advice of the Overseeing Organisation should be sought.

9. REFERENCES AND BIBLIOGRAPHY

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Specification for Highway Works (SHW) (MCHW 1)

Notes for Guidance on the Specification for Highway Works (NG SHW) (MCHW 2)

Highway Construction Details (HCD) (MCHW 3)

2. **Design Manual for Roads and Bridges (DMRB) (The Stationery Office)**

HD 33 – Surface and Sub-surface Drainage Systems for Highways (DMRB 4.2)

HD 35 – Conservation and the use of Secondary and Recycled Materials (DMRB 7.1.2)

HA 56 – The Good Roads Guide: New Roads Planting, Vegetation and Soils (DMRB 10.1.2)

HA 83 – Safety Aspects of Road-edge Drainage Features (DMRB 4.2)

HA 98 – Nature Conservation Management Advice in Relation to Amphibians (DMRB 10.4.6)

HA 103 – Vegetative Treatment Systems for Highway Runoff (DMRB 4.2)

HA 119 – Grassed Surface Water Channels for Highway Runoff (DMRB 4.2)

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16. ESCARAMEIA, M. and TODD, A.J., Grassed surface water channels for road drainage, Project Report, Report SR 662, HR Wallingford, 2006.

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3 Network Management Manual and Routine & Winter Service Code (NMM & RWSC). Highways Agency. (The Stationery Office).

4 CARSWELL, J. and JENKINS, E.J., Re-use of scrap tyres in highway drainage, TRL Report 200. 1996.

10. ENQUIRIES

All technical enquiries or comments on this Advice Note should be sent in writing as appropriate to:

Division Director of Network Services – Technical Services Division The Highways Agency City Tower Manchester M1 4BE	D DRYSDALE Division Director of Network Services – Technical Services Division

Director, Major Transport Infrastructure Projects Transport Scotland 8th Floor, Buchanan House 58 Port Dundas Road Glasgow G4 0HF	A C McLAUGHLIN Director, Major Transport Infrastructure Projects

Chief Highway Engineer Transport Wales Welsh Assembly Government Cathays Parks Cardiff CF10 3NQ	M J A PARKER Chief Highway Engineer Transport Wales

Director of Engineering The Department for Regional Development Roads Service Clarence Court 10-18 Adelaide Street Belfast BT2 8GB	R J M CAIRNS Director of Engineering

APPENDIX A SPECIFICATION FOR BITUMEN BOUND TOPPINGS

Specification for Bitumen bound materials as topping to Combined Surface and Sub-surface Drains

Refer to Chapter 4

A.1 The shredded tyre used in the surfacing should be supplied to a grading, comparable to that of Type B, shown in Table 5/5 of the SHW (MCHW 1).

A.2 The binder should be a blend of penetration grade bitumen to BS EN 12591 (Ref 20), polystyrene/polybutadene/polystyrene block copolymer (SBS thermoplastic rubber) and inert, inorganic filler. Bitumen/SBS blends are elastic materials that are non-leachable by aqueous media. The proportion of binder should be approximately 25% ± 5% by weight of the overall mix.

A.3 The graded tyre shreds should be site mixed with bitumen binder heated to a temperature of between 150 and 190°C.

A.4 The mixing process takes approximately 20 minutes before the material can be discharged directly into the combined surface and sub-surface drain trench where it may then be hand spread. The temperature at discharge should be between 100 and 160°C.

A.5 The bitumen bound tyre surfacing should be rolled with one or two passes of a single drum vibrating roller weighing not more than 450 kg per metre width of vibrating roll to ensure that it is compressed into a homogeneous matrix. Over compaction will reduce the void volume and adversely affect the permeability of the finished surface. The surfacing should be allowed to cure for approximately one hour.

A.6 Coloured emulsion may be applied to the finished surface to clearly differentiate between the carriageway and the drain surfaces. Red can act as a visual warning while beige gives a natural stone effect. Alternative colour finishes may be applied further to consultation with the Overseeing Organisation.

A.7 As discussed in paragraph 4.3, the permeability of bitumen bound shredded tyre topping is somewhat lower than for conventional filter material. Clause 8.5 of HA 83 (DMRB 4.2) draws the designers attention to the need to dish the surface of the capped combined surface and sub-surface drain. This feature may be incorporated into the bitumen bound shredded tyre surfacing as a means of diverting high flows to outlet gratings without hazard to road users. The slope of any channel should not be steeper than 1 in 5.

A.8 Experience has shown that this material tends to become clogged along the edge adjacent to the pavement. An alternative arrangement is to form a crossfall over the surfacing sloping away from the pavement edge, surface water will naturally flow towards the rear of the drain. This will reduce the risk of ponding.

A.9 Where bitumen bound topping material is used next to grated catchpits or chambers, pieces of shredded tyre can become detached from the matrix.

A.10 The Design Organisation should consider what special precautions, if any, should be taken to ensure that pieces of the topping material do not enter the drainage system through any gratings or other openings.

A.11 Bitumen bound shredded tyre material produces a stiff matrix that should be capable of supporting pedestrians and cyclists. However, the shredded tyre used in the process does contain a small amount of steel. The Design Organisation should consider whether any exposed steel may present a potential hazard to cyclists and pedestrians.

Specification for Bitumen bound Aggregate Topping for Combined Surface and Sub-surface Drains

Refer to Chapter 4

A.12 This applies only to the top 200mm of combined surface and sub-surface drains. The material may be applied either to complete the backfilling of a new combined surface and sub-surface drain or to an existing drain after prior removal of the uppermost 200mm of existing material.

A.13 The combined surface and sub-surface drain aggregate should graded in accordance with Type B in Table 5/5 of Clause 505 the of SHW (MCHW 1).

A.14 The mixture should contain the following percentages by mass of the total mixture. Either:

(i) 2% hydrated lime; or

(ii) 4% ordinary Portland Cement; or

(iii) not greater than 1.5% Stearine Amine or other wetting agent, and then only provided that no drainage of the binder occurs from the aggregate takes place during transport to the point of placing.

Binder

A.15 The binder should be non-leachable by aqueous media. Depending on the application, the selected binder should be either:

(a) 160/220 pen bitumen; or

(b) 160/220 pen bitumen with natural rubber latex or powder; or

(c) a modified binder with a BBA HAPAS Roads and Bridges certificate for this usage. In the event that no such certificates have been issued, modified binders should not be used with out the approval of the Overseeing Organisation.

A.16 The bitumen in Options (a) or (b) should be paving grade bitumen complying with the requirements of BS EN 12591 (Ref 21). Material using unmodified 160/220 pen bitumen should only be used on all purpose roads where permitted.

Binder in Recipe Mixtures

A.17 Recipe mixtures should use 160/220 pen unmodified bitumen with a target binder content of 3.4% when the coarse aggregate is crushed rock and 4.3% when it is slag. The manufacturing tolerance of the target binder should be ±0.3%.

Binder in Design Mixes

A.18 For design mixes the target binder content should be calculated in accordance with the Binder Drainage Test in DD 232: 1996 (Ref 22), except that the binder contents used should be 2.5, 3.0, 3.5, 4.0 and 4.5% by mass respectively. The Binder Drainage Test should be carried out at the following temperatures:

(i) using 160/220 pen bitumen	125°C ± 3°C
(ii) using natural rubber latex or powder	150°C ± 3°C
(iii) for modified binders	In accordance with the manufacturer's recommendations

Table A1 – Binder Drainage Test

A.19 The Binder Drainage Test should be carried out at the mid-point of the grading limits using the same coarse aggregates and filler option as proposed for use in the Works.

A.20 The target binder content should be lesser of the calculated target binder content and 4.5%. The mixture should not be used where either:

(a) the target binder content<3.0% when using unmodified 160/220 pen bitumen; or

(b) the target binder content <4.0% when using a modified binder.

A.21 The manufacturing tolerance on the target binder content should be ±0.3%.

A.22 Plant mixes should be manufactured using the same aggregates, filler and binder used in the Binder Drainage Test. The mixing temperature should not exceed that specified in Table A1 for the Binder Drainage Test.

Mixing, Delivery and Compaction

A.23 Bitumen bound aggregate should not be mixed, delivered, laid and compacted within the material temperatures given in Table A2:

Max/min temperature (as specified) points of measurement	Temperature (ºC)		
	Bitumen grade/blend		
	160/220 pen	160/220 pen + NR	160/220 pen + other
Max mixing	135	135	†
Min delivery	95	95	†
Min paver-out*	85	85	†
Min compaction ‡	65	65	†

NR = Natural Rubber
Other = Modified other than natural rubber
† In accordance with the supplier's recommendation
* These values are required in order to achieve the maximum available compaction time. They are useful for monitoring purposes to ensure that adequate compaction time is available.
‡ This is the temperature at which substantial completion of the compaction should have been achieved.

Table A2 – Maximum and Minimum Temperatures

A.24 The temperature of the delivered load and the load in the hopper should be checked according to the method in BS 598: Part 109 (Ref 21) at the following intervals:

(a) in the vehicle within 30 minutes of arrival on site; and

(b) in the vehicle just prior to discharge

A.25 The bitumen bound aggregate mixture should be placed in layers of 100mm nominal thickness. The layer should be rolled using 1 or 2 passes of a single drum vibrating roller of deadweight not more than 450kg per metre width of vibrating roll. The object of this is to compact the material into a matrix while minimising the reduction in voids. Over compaction should be avoided. Rolling should be completed with adequate time margin before the material has cured and should be substantially completed before the surfacing temperature has fallen to the minimum compaction temperature in B12 above.

A.26 An end performance test of permeability should be undertaken in-situ on the new material using a constant head permeameter in accordance with BS 1377: Part 5 (Ref 8). The average coefficient of permeability from any 5 consecutive determinations at 10m intervals should be between 0.015 and 0.025 m/s.

A.27 Surplus material should be carefully removed from the carriageway and verge following placing and compaction.

A.28 Note that rutting can be a problem where over run and bound chunks are scattered on to the carriageway, although there is little evidence of this and the effects have not been monitored.