

## Development of Standard Specification and Standard Details for Local Highway Maintenance

### Appendix 1 – Specification & Notes for Guidance

Version 1 – November 2012



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# REVISION SCHEDULE

Rev	Date	Details	Prepared by	Reviewed by	Approved by
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This document is released as an Interim Document to allow its use by local highway authorities as early enablers in the development of their term service contracts, feeding into the ongoing development of the Highways Maintenance Efficiency Programme Standard Term Maintenance Contract and Document Compiler work package.

If you wish to make a comment or contribute to the development of the document, please send an email to

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with the header 'Feedback on the Standard Specification and Standard Details'.

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# FOREWORD

## ABOUT THE HIGHWAYS MAINTENANCE EFFICIENCY PROGRAMME

The Highways Maintenance Efficiency Programme (HMEP) is a sector-led transformation initiative that will maximise returns from investment and deliver efficiencies in highway maintenance services. The Programme started in April 2011 with sponsorship from the Department for Transport and is intended to run until 2018.

The Programme is offering local highway practitioners benefits from different ways of working. The vision is that over time, those involved in highways maintenance delivery, the local authorities as clients and their service providers, be they from the private or public sector will adopt an ambitious and longer-term approach to enable them to:

- Continuously find new and improved ways of delivering services to highway users and managing highways assets.
- Make use of collaborative partnerships to improve processes and outcomes.

Deliver a sustainable balance between meeting the needs of highways users, improving quality and minimising costs.

The overall programme has been developed by the Programme Board through key personnel who support HMEP's development. This will ensure that:

- The Programme is truly being driven by what the whole sector needs and wants ('by the sector for the sector').
- The solutions identified by the sector are relevant, realistic, repeatable, scalable and sustainable.
- HMEP is benefits-led, driving true transformation of the sector with tangible efficiency gains and a lasting legacy.

As a transformation initiative HMEP is targeting the ways local highway authorities conduct their business. It invites the sector to adopt new ways of working to deliver efficiency savings through:

- **Collaboration & Change** - looking at how alliances between authorities, and clients and their providers, can be formed to deliver efficiencies in the delivery of highway maintenance services. Other projects are looking at changing business processes; for instance by applying Lean thinking to the processes behind service delivery and how services or processes can be streamlined to realise efficiencies.

- **Procurement, Contracting and Standardisation** – advising on the routes to procurement enabling authorities to determine how their current service is aligned to current thinking and which is the best procurement option to realise their future service ambitions. It also provides the tools so that efficiencies can arise through the use of, for instance, a standardised form of contract and highway maintenance specification which are better aligned to the activities that local highway authorities undertake.
- **Asset Management** – by providing advice to the sector in the form of updated asset management guidance; for both a simplistic and, where appropriate, more complex lifecycle planning tool to determine whole life asset costs, thus moving away from a reactive to a longer-term approach for maintaining highways assets. To provide training specifically targeted at practitioners to help them move towards an asset management approach and to adopt the new HMEP guidance and tools.
- **Benchmarking & Performance** – collecting, sharing and comparing performance data on Customer/Quality/Cost to help both understanding to show how effective local highway authorities are in delivering Value for Money services and drive targeted efficiencies.

Products and tools are being developed for each of these themes and are being designed to be interdependent, but complementary, so that authorities can maximise their returns from their investments.

## ABOUT THIS TOOLKIT

The HMEP survey of the sector of October 2011 indicated that 97% of those local highway authorities responding wanted a specification that was more aligned to the maintenance activities that they undertake, as opposed to the current Specification for Highway Works which is aimed at new road construction. In response to this, HMEP has prepared this guidance for the development of a Standard Specification and Standard Details for Local Highway Maintenance.

This is the first release of the document and is aimed at the areas where local highway authorities incur the greatest maintenance expenditure; namely in highway drainage, kerbing and footway works, bituminous surfacing, structural concrete, structural steelwork and winter maintenance activities. The guidance is based on documents returned as part of each authority's response to the survey. The content of this guidance draws on the good practice within specifications developed for recent tenders and for contracts that are about to be procured, making the content as current as possible.

This guidance represents the beginning of a review of the full range of services local highway authorities undertake. A new product is currently in development that will expand on the scope of the guidance to all series of the specification and incorporate outcome specifications. This is programmed for release towards the end of 2013. However, the sector is encouraged to start to move towards a standardised approach by using this document.

A consistent approach will help to align the documents to the range of services that local highway authorities undertake with associated pricing schedules, method of measurement and bill item generation. This product will be presented with the HMEP suite of procurement documents (IfT, OJEU, PQQ and Form of Contract) within a document compiler platform to enable local highway authorities to procure Term Service Contracts as well as individual projects while moving towards an e-tendering solution.

Significant savings are expected through adopting a standard specification across the sector. The many bespoke forms that currently exist will be rationalised to a single common form. The HMEP version will also be maintained centrally and be updated regularly, saving the resource commitment within each authority to update and maintain their own standard forms. There is also the potential for wider savings throughout the supply chain as all become familiar with the new specification and move away from bespoke forms towards a consistent approach. Authorities are therefore encouraged to start using this guidance now to move towards the aims and ambitions of the wider programme for the sector.

Authorities should resist the temptation to bespoke the specification to suit their particular local needs. If you consider that certain aspects need to be included, please relay the information with the rationale for its inclusion back to the Programme for consideration. If deemed appropriate, it will be included within the next update.

## ABOUT THIS DOCUMENT

This document forms Appendix 1 to the Guidance for the Development of Standard Specification and Standard Details for Local Highway Maintenance Contracts, and contains the Specification and Notes for Guidance clauses developed as part of the HMEP.

Users should refer to the original document for references to the specification and notes for guidance.

## COMMENTS AND FEEDBACK

The HMEP Programme Board would welcome any comments and feedback on this document so that the final product may be reviewed, improved and refined to give the sector the best advice possible. If you wish to make comments please email them to [highwayefficiency@DfT.gsi.gov.uk](mailto:highwayefficiency@DfT.gsi.gov.uk) with the header 'Feedback on the Standard Specification and Standard Details' for local highway maintenance contracts.

## INTRODUCTION

The Guidance for the Development of Standard Specification and Standard Details for local highway maintenance Contracts has been prepared on behalf of the Highways Maintenance Efficiency Programme to provide a series of standard specification items and drawings for local highway authority maintenance works.

The Department for Transport published Manual of Contract Documents for Highways Works was originally developed for the specification of new works on the motorway and trunk road systems, and has been recognised that it has limitations in its use when specifying maintenance materials for local highway authorities.

Many local highway authorities have, either individually or collaboratively, developed their own variations to the Manual of Contract Documents for Highways Works, illustrating the need for specific items to cover the works undertaken on non-motorway or trunk road routes.

The Highways Maintenance Efficiency Programme (HMEP) has collated these variations, drawn the common themes from the information provided by local authorities, and identified examples of good practice. Material specifications have been standardised where possible to enable cost savings and increased confidence in material quality to be achieved through a consolidation or rationalisation of the available information.

## DOCUMENT RELEVANCE

During the development of this document it has been recognised that, to bring maximum benefit to users, additional work is required to expand the current HMEP specification to cover all works undertaken by local highway authorities. In addition it is noted that the Department for Transport is in the process of updating the Specification for Highways Works. The nature and extent of this update is not known at present. As a result this document will require updating within 12 to 18 months.

This work will contribute to a new HMEP product comprising a Standard Term Maintenance Contract and Document Compiler. The scope of this package is to provide Term Maintenance Contract, Method of Measurement and Bill of Quantities for highway maintenance services associated with two other HMEP products (the Form of Contract and Specification).

**This document is therefore released as an Interim Document to allow its use by local highways authorities as early enablers in the development of their term service contracts, feeding into the ongoing development of the Highway Maintenance Efficiency Programme Standard Term Maintenance Contract and Document Compiler work package.**

Following completion of the Highway Maintenance Efficiency Programme Standard Term Maintenance Contract and Document Compiler this document will be revised to take into account feedback over the development period.

## DOCUMENT LAYOUT

The Guidance for the Development of Standard Specification and Standard Details for Local Highway Maintenance Contracts document has been developed in three sections:

### **Section 1: Guidance for the Development of Standard Specification and Standard Details for Local Highway Maintenance Contracts**

The main document provides information on the background to the HMEP work undertaken to date, and on the development of this product.

### **Section 2: Appendix 1 - Specification and Notes For Guidance (This Appendix)**

The Standard Specification document has been sub-divided into the relevant Specification for Highways Works series. The work has been further divided within each series into:

**Specification** - The HMEP guidance provides two forms of specification clauses. These are numbered as HMEP Cl. Xxx, and may be used as Substitute Clauses, SR, replacing the current Specification for Highways Works Clause, or as an Additional Clause, AR, to the existing Specification for Highways Works. Where additional Notes for Guidance for the Specification clause have been provided the full specification clause has been supplied.

**Notes for Guidance** – Where applicable notes for guidance for the alternate clause have been produced. These are highlighted in an orange box (shown below) and follow the relevant clause. These are numbered as HMEP NG Cl. Xxx



**Additional Guidance** – Additional guidance notes have been included where information has been obtained that can be used to aid decisions on the adoption of specification items, or where additional guidance is available from other sources.

These are also highlighted in an orange box (as above), and are numbered as HMEP AG xxx.xx.

### **Section 3: Appendix 2 - Standard Details**

Standard detail drawings have been prepared to supplement those provided in the Manual of Contract Documents for Highways Works Highways Construction Details and to expand on the HMEP Standard Specification above. These provide additional standard details for local highways works on non-motorway or non-trunk road systems. They include additional drainage details for minor roads and footway construction details.

The standard details drawings are numbered HMEP – XXX – YYY, where XXX is the Specification for Highways Works series number, and YYY is the sequential numbering for the drawings. These are available separately from this document for download from

the HMEP website as .pdf and .dwg files. These drawings may be referred to either in their original form in this document, or imported into specific contract documents.

In the event that the drawings are imported into contract documents the drawings should be renumbered as contract specific drawings in Appendix 0/4 of the new contract.

## SPECIFICATION AND NOTES FOR GUIDANCE

The intention of this document is to provide a set of current standard details that can be used as a core document in specifying highway maintenance services for local highway networks, complementing local details and methods of work.

When referring to a HMEP specification clause in your documentation use the following description

“in accordance with HMEP Clause xxx”

This means that the reference in your document will be taken from the HMEP Clause, which will ensure that it is up to date with any revisions.

Alternatively, consent is given for you to copy the clause from this document into your authorities' document. If you wish to copy items within this document this is acceptable, but will mean that your clause is only as up to date as the version of the document that you hold. References to the HMEP clause numbers should also be removed from the HMEP standard detail drawings and replaced with your clause number taken from your Specification document.

The following apply to each clause unless otherwise stated thereon:

1. Specification for Highways Works means the Specification for Highway Works published by The Stationery Office as Volume 1 of the Manual of Contract Documents for Highway Works.
2. HMEP means the Highways Maintenance Efficiency Programme Standardised Specification and Standard Details For local highway authorities
3. Reference to a Clause prefaced by Cl. is a reference to a Clause of the Specification for Highway Works.
4. Reference to a Clause prefaced by HMEP Cl. is a reference to a Clause of the Highways Maintenance Efficiency Programme Standard Specification.
5. Reference to a Numbered Appendix (e.g. Appendix 3/1) is a reference to a Numbered Appendix to the contract Specification.

The relevant publication date of each Clause is to be determined from the Schedule of Pages and Relevant Publication Dates in the Specification.

The relevant publication date of each British Standard (BS) and other reference document referred to in the HCD is to be determined in accordance with Clause 004 of the Specification.

## SERIES 500 – DRAINAGE AND SERVICE DUCTS

Following review of the information provided by the contributing local authorities from the survey in October 2011 it became apparent that there were limited alterations to the Manual of Contract Documents for Highways Works, Specification for Highways drainage works, and that these could be attributed to individual projects or local variations. For the purposes of the project these were considered in light of their possible provenance and a judgement on their use taken, based upon common themes from other authorities.

One area that was highlighted as needing attention for highway maintenance activities was the specification of methods and materials for the reinstatement of carriageway ironwork following localised failures. This has been carried forward into the work in Series 900, Bituminous Bound Materials.

Another area where additional information was identified was in the provision of standard detail drawings for drainage works. While this area is fully covered in the Manual of Contract Documents for Highways Works - Highways Construction Details these details relate to works on new carriageways. After examining the standard details used by local highways authorities provided by the contributing authorities it became apparent that many of the details had been developed over time from a common source, possibly from details used for foul and surface water sewers when local authorities were responsible for their maintenance. These details have been collated and a series of standard details prepared to cover the majority of uses.

The table below lists the current Clauses from the Specification for Highways Works and alternate Clauses developed by the HMEP for local highways authority use. As noted above, in addition a range of standard detail drawings have been developed to cover the detailing of drainage works for local authority highway works.

Contents List

Series 500 – Specification for Highways Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
501	(05/01) Pipes for Drainage and Service Ducts	501 SR	Pipes for Drainage and Service Ducts
502	Excavation for Pipes and Chambers	502 SR	Excavation for Pipes and Chambers
503	(11/05) Bedding, Laying and Surrounding of Pipes	503 SR	Bedding, Laying and Surrounding of Pipes
504	Jointing of Pipes	504 SR	Jointing of Pipes
505	Backfilling of Trenches and Filter Drains	505 SR	Backfilling of Trenches and Filter Drains
506	Connecting to Existing Drains Chambers and Channels	-	-
507	(05/01) Chambers	507 SR	Chambers
508	Gullies and Pipe Junctions	508 SR	Gullies and Pipe Junctions
509	Testing and Cleaning	509 SR	Testing and Cleaning
510	Surface Water Channels and Drainage Channel Blocks	510 SR	Surface Water Channels and Drainage Channel Blocks
511	Land Drains	511 SR	Land Drains
512	Backfilling to Pipe Bays and Verges on Bridges	512 SR	Backfilling to Pipe Bays and Verges on Bridges
513	Permeable Backing to Earth Retaining Structures	513 SR	Permeable Backing to Earth Retaining Structures
514	Fin Drains	514 SR	Fin Drains
515	Narrow Filter Drains	515 SR	Narrow Filter Drains
516	Combined Drainage and Kerb Systems	516 SR	Combined Drainage and Kerb Systems

Table Continued			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
517	Linear Drainage Channel Systems	517 SR	Linear Drainage Channel Systems
518	(05/01) Thermoplastics Structured Wall Pipes and Fittings	518 SR	Thermoplastics Structured Wall Pipes and Fittings
519	(05/01) Concrete Bagwork	-	-
520	(05/01) The Cleaning of Existing Drainage Systems	520 SR	The Cleaning of Existing Drainage Systems
521	(11/03) Low Pressure High Volume Jetting of Drainage Systems	521 SR	Low Pressure High Volume Jetting of Drainage Systems
-	-	570 AR	Reinstatement of Failed Chamber Covers and Gully Gratings

## HMEP CL 501 SR - PIPES FOR DRAINAGE AND FOR SERVICE DUCTS

### General

1. Where the term drain is used in this Series it shall be deemed to include the terms sewer and piped culvert.

The Contractor shall design the piped culverts listed in Appendix 1/10 in accordance with the requirements of Clause 106.

Series 8000 (Manual of Contract Documents for Highway Works 5.8.2) applies to the installation by trenchless techniques of highway drainage, service ducts, sleeves and culverts with internal diameters up to and including 900 mm nominal internal diameter or width.

2. All drains constructed of pipes as well as piped culverts up to and including 900 mm internal diameter shall comply with this Series and any additional requirements in Appendix 5/1. Drains constructed using pipes exceeding 900 mm internal diameter as well as box and piped culverts shall comply with Series 2500. Unless otherwise

described in Appendix 5/1 only one type of pipe shall be used within any individual drain or service duct between consecutive chambers. The Contractor shall ensure that plastic pipes are not subject to deterioration due to sunlight during the period

### Pipes for Drainage

3. Pipes for drainage shall be selected from the alternatives in Table 5/1 and shall comply with the standards and particular requirements therein. The Contractor shall show that the pipes selected have hydraulic flow capacity equal to that adopted in the hydraulic design of the system as described in Appendix 5/1. Pipes and fittings other than those included in Table 5/1 shall be permitted provided that they hold a current British Board of Agrément Roads and Bridges Certificate (or equivalent) stating that they are a suitable alternative for the usage specified in Table 5/1. On completion of the whole of the drainage works, the Contractor shall provide the Overseeing Organisation with a schedule showing details of all pipe types used, including quality, joints and name of manufacturer.

### Corrugated Steel Pipes

4. Corrugated steel pipes shall be manufactured from either:
  - (i) Bolted segmental plate pipes complying with sub-Clause 6 of this Clause and having plate thicknesses as described in Appendix 5/1; or
  - (ii) Galvanized steel sheet suitable for lock seam fabrication complying with BS EN 10327 grade DX51D + Z600, or aluminium coated steel sheet complying with AASHTO specification M274-87(2004).

Corrugated steel pipes complying with (ii) above shall be manufactured from steel of minimum thickness 1.25 mm unless otherwise described in Appendix 5/1.

5. Where described in Appendix 5/1 corrugated steel pipes shall be provided with additional protection of hot applied bitumen complying with AASHTO specification M190-95(2000), or an equivalent coating system.
6. Bolted segmental plate pipes shall meet the following requirements:
  - (i) Steel for the plates shall comply with BS 1449 : Part 1.1, Grade 3 or Grade 4, Condition HR.
  - (ii) After forming, the depth of the corrugations shall be within a tolerance of  $\pm 6\%$  and the pitch of the corrugations within a tolerance of  $\pm 4\%$  of the nominal dimensions. Plates shall have a minimum lip of 45 mm beyond each end crest. Cut edges shall be free from notches, gouges, rust or burrs.
  - (iii) Bolts and nuts for connecting plates shall comply with BS EN ISO 4014, BS EN 4017 and BS EN ISO 4032, for BS EN ISO 898-1 and BS EN 20898-2, ISO 898-2 property class 8.8, nominal size M20; or with BS 4395: Part 2, nominal size M20; or with BS EN ISO 898-1 and BS EN 20898-2, ISO 898-2 property class 10.9.

- (iv) When all the plates have been assembled, the nuts shall be tightened against a domed washer. The tightening shall be repeated if necessary to achieve the torque recommended by the manufacturer.
- (v) Steel plate shall be galvanized in compliance with Clause 1909. Plates shall be galvanized after forming the corrugations and completing all necessary cutting, punching and drilling. Units in which the zinc coating has been burned by welding or otherwise damaged in fabrication, transport or handling at Site shall be made good in compliance with Clauses 1907 and 1908. Bolts and nuts shall be galvanized in compliance with Clause 1909.

<b>Material</b>	<b>Usage</b>	<b>Standard</b>	<b>Particular Requirements</b>
Vitrified clay	Foul drains	BS 65 or BS EN 295	“Normal” pipes as defined in BS 65
	Surface water drains	BS 65 or BS EN 295	“Normal” or “surface water” pipes as defined in BS 65
	Filter drains	BS 65 BS EN 295	Unperforated, not exceeding 2.0 m in length with spigot and socket open joints  OR  Perforated with flexible mechanical joints
Concrete (With Portland cement or sulphate-resisting cement when required in Appendix 5/1. Super-sulphated cement shall not be used)	Foul & surface water drains not exceeding 900 mm internal diameter	BS 5911-1 and BS EN 1916 (Ordinary reinforced or unreinforced)	
		BS 5911-5	
	Surface water drains not exceeding 900 mm internal diameter	BS 5911-110	For use with joints complying with sub-Clause 504.4
	Filter drains	BS 5911-114 (Porous with ogee or rebated joints)	

Table 5/1 SR – Pipes for Drainage: continued			
Material	Usage	Standard	Particular Requirements
		BS 5911-110	Unperforated not exceeding 2 m in length with open joints or castellated rebated joints with the total slot area between castellations being at least 1000 mm <sup>2</sup> per metre length of pipe  OR  Perforated with circular holes not greater than 10 mm nor less than 3 mm in diameter
Glass reinforced plastics (GRP)	Foul & surface water drains	BS 5480	Class to be as specified in Appendix 5/1
Iron	Foul & surface water drains	BS 437 (Cast iron)  BS EN 598 (Ductile iron)	
Thermoplastics solid wall pipes and fittings not exceeding 900 mm diameter  Unplasticised polyvinyl-chloride (PVC-U)  Polypropylene (PP)  Polyethylene (PE)	Foul & surface water drains	BS 4660 or BS 5481  or BS EN 1401 (PVC-U)  BS EN 1852-1 (PP)  BS EN 12666-1 (PE)	See the UK national guidance for the relevant BS EN. The grade appropriate for use without structural calculations shall be used i.e. SN8 for PP & PE and SN4 (SDR 41) for PVC-U
	Filter drains	BS 4660 or  BS 5481 or  BS EN 1401 (PVC-U)  BS EN 1852-1 (PP)  BS EN 12666-1 (PE)	Perforated with not less than 1000 mm <sup>2</sup> of holes per metre length of pipe. The perforations shall not reduce the pipe stiffness by more than 5%. Circular perforations not greater than 10 mm nor less than 3 mm in diameter or rectangular slots not greater than 4 mm nor less than 0.6 mm in width

Table 5/1 SR – Pipes for Drainage: continued			
Material	Usage	Standard	Particular Requirements
Thermoplastics structured wall pipe and fittings not exceeding 900 mm diameter	Surface water drains	Clause 518	Unperforated with watertight joints and with a pipe stiffness class, creep ratio and impact resistance as described in Appendix 5/1
	Filter drains	Clause 518	Perforated with not less than 1000 mm <sup>2</sup> of holes per metre length of pipe. The perforations shall not reduce the pipe ring stiffness by more than 5%. Circular perforations neither greater than 10 mm nor less than 3 mm in diameter or rectangular slots neither greater than 4 mm nor less than 0.6 mm in width
	Subsoil field drains	BS 4962 or Clause 518	
Corrugated steel	Surface water drains, filter drains not exceeding 900 mm internal diameter	AASHTO specification M36M-01 except as otherwise required in sub-Clauses 501.4, 5 and 6	
All drains exceeding 900 mm internal diameter shall comply with Series 2500.			

### Pipes for Service Ducts

7. Pipes for service ducts shall be selected from the alternatives in Table 5/2 and shall comply with the standards and particular requirements therein. Pipes for other service ducts installed using trenchless methods shall conform to Series 8000 Manual of Contract Documents for Highway Works 5.8.2. Pipes for service ducts shall have a smooth internal bore without any sharp edges to the ends of pipes. They shall comply with any additional requirements described in Appendix 5/2, and be of 100 mm internal diameter unless otherwise described therein. Their alignment shall be tested in accordance with sub-Clause 509.9. The use of pipes and fittings other than those included in Table 5/2 shall be permitted provided that they hold a current British Board of Agrément Roads and Bridges Certificate (or equivalent) stating that they are a suitable alternative to those listed in Table 5/2.
8. Each duct shall be fitted with a pigmented, stranded polypropylene or equivalent rot-proof material draw rope of 5 kN breaking load and having a design life of not less

than 20 years, the ends of which shall be either made fast to marker blocks as shown on HCD Drawing Number I1 or secured inside chambers. The ends of a duct shall be either sealed by removable stoppers immediately it has been laid, or terminated in chambers of the type specified in Appendix 5/2.

<b>Table 5/2 SR – Pipes for Service Ducts</b>		
<b>Material</b>	<b>Standard</b>	<b>Particular Requirements</b>
Vitrified clay	BS 65 or BS EN 295	Plain-ended, self-aligning flexible sleeve jointed with internal ends radiused to 3 mm minimum
Iron	BS EN 598  (Ductile iron)	
Glass reinforced plastics	BS 5480	Class to be as specified in Appendix 5/2
Thermoplastics solid wall  Unplasticised polyvinyl-chloride  (PVC-U)          Polypropylene (PP)          Polyethylene (PE)	BS 4660 or  BS 5481 or  BS 3506 (Class C) or  BS EN 1401,  BS EN 1452-1 to 5 as appropriate class PN10.          BS EN 1852-1 (PP)          BS EN 12666-1 (PE)	When pipes BS 3506 (Class C) are used, joints shall comply with BS EN 1452-1 to 5 as appropriate
Thermoplastics single wall corrugated  (Restricted to ducts buried a minimum of 600 mm below the surface)	BS EN 50086-2-4	Ducts to BS EN 50086-2-4 shall be classified as normal duty, have a degree of protection against ingress of foreign objects classification rating of 3 or 4 and a degree of protection against ingress of water classification rating of 7. Appendix 5/2 shall state the resistance to bending requirements.

Material	Standard	Particular Requirements
Thermoplastics structured wall	BS EN 50086-2-4 and Clause 518	Ducts to BS EN 50086-2-4 shall be classified as normal duty, classification rating of 3 or 4 and a degree of protection against ingress of water classification rating of 7. Appendix 5/2 shall state the resistance to bending requirements.

## HMEP NG 501 PIPES FOR DRAINAGE AND SERVICE DUCTS

1. Pipes can be made of materials that deflect relatively little under load before cracking (rigid pipes) or of materials that will tolerate large deflections under load before inward buckling occurs (flexible pipes). Flexible joints enable either type of pipe to take up differential settlement within the ground.
2. The Specification includes a wide range of pipe materials. The Contractor should normally be offered in Appendix 5/1 the full selection of alternative pipe and bedding combinations determined in accordance with Advice Note HA 40 (DMRB 4.2.5) as detailed in the HCD for pipes up to 900 mm internal diameter. The required pipe stiffness and impact resistance for plastics pipes should be specified in Appendix 5/1. The requirements for thermoplastics pipes and fittings will normally be as in Clause 518 with raw material and quality control requirements as in NG 518.

Piped culverts up to 900 mm internal diameter should be specified in Series 500. Drains, box culverts, piped culverts (and other drains) of clear span or internal diameter exceeding 900 mm are subject to the Overseeing Organisation's technical approval and should comply with Series 2500. A box culvert should not be specified where either a (concrete) box culvert or a (corrugated steel) piped culvert would be technically acceptable. Wherever possible, the Contractor should be offered a choice and the Overseeing Organisation should be consulted during the scheme preparation. Box culverts, piped culverts (and other drains) of clear span or internal diameter exceeding 900 mm are structures subject to the Overseeing Organisation's technical approval. Care should be taken to ensure that there are no inconsistencies between any specific requirements included in an outline Approval in Principle form and the general requirements of Series 500. Where necessary, Contract-specific amendments should be included in Appendix 0/1 or 0/2 to achieve consistency.

Most of the pipes included in the Specification will normally be satisfactory from the hydraulic flow capacity factor. However some products, especially corrugated pipes, can

vary from the norm clay/ concrete and between manufacturers. The effect of a rougher pipe should be considered on the system as a whole and not just on the length in question. A pipe which is not acceptable on a straight exchange basis may be acceptable if diameters on adjacent lengths are adjusted. Appendix 5/1 should provide the basis on which the Contractor is to submit his proposals for pipe types and makes.

3. Any tendency to attack by acidic ground water or sulphates present in the backfill or the ground should be taken into account when the use of concrete, asbestos cement, steel or iron pipes is being considered for inclusion in the schedule of acceptable alternatives in Appendix 5/1.

The advice described in Clause NG 1704 should be considered regarding the risk of thaumasite sulphate attack on concrete used in drainage.

When acid soils (pH less than 6.5) are encountered, expert advice should be sought. There is some evidence that pipes made of sulphate-resisting cement and asbestos cement pipes will tolerate a pH as low as 6.0. The limiting value may be reduced to pH 5.5 when a bitumen coating is applied to the pipe. Sulphate attack on concrete is dealt with in Building Research Establishment Special Digest 1. Asbestos cement pipes will tolerate the same order of sulphates as concrete made from sulphate-resisting cement. More detailed information may be obtained from the manufacturers.

Protection to the lower third of the inside of corrugated steel piped culverts by means of an asphalt or insitu concrete coating will be required where stones and rocks are likely to be carried by the flow. Iron pipes are treated with a pitch or bitumen coating and have high durability in most soils, but when acid conditions are known to be present the additional protection of a polyethylene sleeve is desirable. Clay, GRP, pitch fibre and PVC-U pipes are resistant to a wide range of groundwater chemicals.

4. For corrugated steel pipes of lock seam fabrication with a diameter not exceeding 900 mm, the specification of metal thickness should be given in Appendix 5/1. The tables issued by manufacturers recommend thicknesses corresponding to the diameter and depth of fill above the pipe.
5. Pipes of more than one type within any individual drain or service duct between consecutive chambers will be exceptional. Whatever the circumstance giving rise to the proposal, consideration should be given to whether the joint between the two pipes will provide an appropriately watertight joint and a smooth inner transition for rodding purposes.
6. Plastics pipes may deteriorate after a long period in sunlight. Where pipes have been manufactured and stored before being delivered to the Site, it may be necessary for the Contractor to cover them until they are installed.

7. Any individual cable duct under a road may have to accept a power or a communication cable although these are normally placed in separate ducts. Certain pipe materials have been excluded from the Specification for use as ducts because cables cannot be readily drawn through them. Clauses NG 518, NG 1421 and NG 1530 give further information on the use of ducts for electrical work. Ducts should be scheduled in a similar way to pipes in Appendix 5/2. Any special requirements of Statutory Undertakers etc. should be stated clearly.
8. Trenchless and minimum dig installation is the means of installing, replacing and renovating pipes, ducts and small tunnels with minimal or no excavation from the surface. Manual of Contract Documents for Highway Works 5, Series 8000 covers the requirements for trenchless and minimum dig installation of highway drainage, service ducts, sleeves and culverts up to and including 900 mm nominal internal diameter or width.

The information required from the designer/compiler that will detail the performance required from the trenchless installation should be given in NG Sample Appendix 80/1 (Manual of Contract Documents for Highway Works 5.8.3).

## HMEP CL 502 SR - EXCAVATION FOR PIPES AND CHAMBERS

1. Excavation shall comply with Clause 602 and with the following:
  - (i) soft spots existing below the bottom of an excavation shall be removed and the resulting voids backfilled with Type 1 unbound mixture for sub base complying with Clause 803 or pipe bedding material complying with Clause 503, both well compacted, or ST1 concrete in compliance to Clause 2602;
  - (ii) any additional excavation below the bottom of an excavation that is required because the Contractor has allowed the bottom to become soft or otherwise unacceptable for the construction of the pipeline or chambers shall be made good as described in sub-Clause 1(i) of this Clause;
  - (iii) any excavation greater than the net volume required for the Permanent Works below the level of any pipe surround shall be made good as described in sub-Clause 1(i) of this Clause.
2. Unless otherwise described in Appendix 5/1, all pipes in or under new embankments shall be laid only when the embankment has been formed and compacted to formation level under paved areas, to finished earthworks level in other areas, or to a level which will give a minimum cover of 1.2 m to the pipes, whichever is the lowest.

### HMEP NG 502 EXCAVATION FOR PIPES AND CHAMBERS

1. In the preparation of Appendix 6/3, it may be considered appropriate to permit battering of slopes where this would not affect adversely the Permanent Works or the basis of structural design of the pipe/ trench.
2. In the event of excavation to a greater depth than necessary the Contractor is obliged to reinstate. The use of ST1 concrete to remedy excess excavation should be restricted to areas where compaction is impracticable. Where the floor of the trench passes through a localised area of disturbed and uncompacted soil or softened clay further excavation and replacement with appropriate material may be required to allow pipe laying to proceed.
3. Where pipes are to be installed beneath heavily trafficked existing roads, etc, where it is undesirable that the existing ground surface should be disturbed, consideration should always be given to the possibility of inserting the pipe by suitable thrust boring or jacking processes.

### HMEP CL 503 SR - BEDDING, LAYING AND SURROUNDING OF PIPES

1. Immediately following the excavation of the trench, the pipes shall be laid and jointed on the pipe bed. Pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel. The pipes shall be laid at the level and gradients shown on the Drawings and schedules. The deviation in level from that specified at any point shall not exceed 20 mm and in addition the algebraic difference of the deviation in level at any two points on each pipe shall not exceed 30 mm. In the case of socketed or sleeve jointed pipes the bed shall be cut away and removed at each socket or sleeve to give a clearance of at least 50 mm, or 100 mm for trenches in material designated as Hard Material, so that the socket or sleeve does not bear on the bed. Pipes shall be laid on setting blocks only where a concrete bed or cradle is used.

Pipes and fittings shall be examined for damage and the joint surfaces and components shall be cleaned immediately before laying. Measures shall be taken to prevent soil or other material from entering pipes, and to anchor each pipe to prevent movement before the work is complete.

2. Pipes complying with BS 4962 : 1989 which are corrugated coilable perforated pipes shall, unless otherwise permitted in Appendix 5/1, be laid only by automatic single pass drain laying machines.
3. Drainage pipe and bedding combinations shall be selected from the alternatives described in Appendix 5/1. The granular material shall consist of natural and/or

recycled coarse aggregate or recycled concrete aggregate complying with BS EN 13242. Where recycled coarse aggregate or recycled concrete aggregate is used in this Clause, it shall have been tested in accordance with Clause 710 and shall not contain more than 1% other materials (Class X). Pipe bedding, haunching and surrounding material shall be as shown on HCD Drawing Numbers F1 and F2, and shall comply with the following:

- (i) For pipes on beds shown on HCD Drawing Number F1 as Types B, F and S the aggregate shall have:
  - (a) geometrical requirements in accordance with Table 5/3;
  - (b) a resistance to fragmentation in Category LA<sub>50</sub> in accordance with BS EN 13242, clause 5.2 and Table 9;
  - (c) a water-soluble sulphate content of less than 0.38% of sulphate (as SO<sub>3</sub>) when tested in accordance with BS EN 1744-1, clause 10;
  - (d) all other requirements in Category NR.
- (ii) For pipes on beds shown on HCD Drawing Number F1 as Types N and T the aggregate shall comply with the geometrical requirements of either Table 5/3 or with Table 5/4, and with the fragmentation, water-soluble sulphate content and other requirements of (i) above.

TABLE 5/3: BS EN 13242, Coarse aggregate for pipe bedding, haunching and surrounding material		
BS EN 13242, Coarse aggregate (clause 4.3.2)		
Category for general grading requirements	GC80-20	
Category for tolerances at mid-size sieves	GT <sub>NR</sub> (no requirements)	
Category for maximum values of fines content	Gravel – $f_{1.5}$ Crushed rock, recycled aggregate - #4	
Nominal pipe diameter, mm	Aggregate size, mm	
	Graded	Single sized
Not exceeding 140	-	4/10
Exceeding 140 but not exceeding 400	2/14 or 4/20	4/10, 6/10 or 10/20
Exceeding 400	2/14, 4/20 or 4/40	4/10, 6/14, 10/20 or 20/40

TABLE 5/4: BS EN 13242, Fine and all-in aggregated for pipe bedding, haunching and surrounding material		
BS EN 13242, Fine and all-in aggregate (clause 4.3.3)		
	Fine	All-in
Category for general grading	Category requirements $GF_{80}$	Category $GA_{80}$
Category for tolerances on manufacturer's declared typical grading	$GT_{F NR}$ (no requirement)	$GT_{A NR}$ (no requirement)
Category for maximum values of fines content	Gravel – $f_3$ Crushed rock, recycled aggregate – $f_{11}$	
Nominal pipe diameter, mm	Aggregate size, mm	
	Fine	All-in
Not exceeding 140		0/10
Exceeding 140 but not exceeding 400	0/1, 0/2, 0/4 or 0/6	0/10 or 0/20
Exceeding 400		0/10, 0/20 or 0/40

- (iii) For pipes on beds shown on HCD Drawing Number F1 as Types A and Z concrete shall be ST4 and ST2, in compliance to Clause 2602, respectively. Backfilling shall not be carried out until after the concrete has cured.
  - (iv) Except for filter drains a further surround above the bed, haunch and surround described above shall be provided to a height of 300 mm above the top of the pipe consisting of Class 8 lower trench fill material as described in Table 6/1 and in compliance with Series 600.
  - (v) Unless otherwise described in Appendix 5/1 the materials used for the bedding, haunching and surrounding of filter drains shall comply with the appropriate bedding, haunching and surrounding materials specified in sub-Clauses 503.3.(i) to 503.3.(iv) and with the requirements for backfilling specified in sub-Clause 505.3.
4. Material for bedding, haunching and surrounding pipes shall not be deposited within 500 mm, or any other distances described in Appendix 5/1, of concrete, cement bound materials, other cementitious materials or stabilised capping forming part of the Permanent Works if, when tested in accordance with TRL Report 447 either:
- (i) the water-soluble sulphate (WS) content exceeds 1500 mg of sulphate (as  $SO_4$ ) per litre (Test No.1); or
  - (ii) the oxidisable sulphate (OS) content exceeds 0.5% of sulphate (as  $SO_4$ ) (Test No.2 and Test No.4); or

- (iii) the 2:1 water to soil extract prepared for the determination of water-soluble sulphate in (i) has a pH value of less than 7.2, when tested using the electrometric method of pH determination in accordance with BS 1377-3.

At least five samples of each material shall be tested for WS, OS and pH value. The mean of the highest two values shall be used for comparison with the limiting values. This also applies if six to nine results are available. If ten or more results are available, the mean of the highest 20% of the results shall be used for comparison with the limiting values.

5. Material for bedding, haunching and surrounding pipes shall not be deposited within 500 mm, or any other distances described in Appendix 5/1, of metallic structural elements forming part of the Permanent Works if, when tested in accordance with TRL Report 447 either:
  - (i) the water-soluble sulphate (WS) content exceeds 300 mg of sulphate (as  $\text{SO}_4$ ) per litre (Test No.1); or
  - (ii) the oxidisable sulphides (OS) content exceeds 0.06% of sulphate (as  $\text{SO}_4$ ) (Test No.2 and Test No.4).

At least five samples of each material shall be tested for WS and OS. The mean of the highest two values shall be used for comparison with the limiting values. This also applies if six to nine results are available. If ten or more results are available, the mean of the highest 20% of the results shall be used for comparison with the limiting values.

The requirements in (i) and (ii) above shall not apply to metallic items protected by concrete and ancillary metallic items such as the tops of chambers and gullies.

6. Except where the pipeline is to be tested in compliance with Clause 509 before backfilling, the completion of the bedding, haunching and surrounding of the pipes is to be carried out immediately after jointing. The bed, haunch and surround shall be brought up equally on both sides of the pipe ensuring that it is in contact with the underside of the pipe barrel and be carefully compacted in layers not exceeding 150 mm thickness ensuring full compaction next to the trench walls. Pipes shall be maintained to line and level during the bedding, haunching and surrounding operations. Where pipelines are to be tested before being covered the bedding haunching and surrounding material shall only be brought up sufficiently to support the pipeline and the joints shall be left exposed until the test is completed satisfactorily.
7. Duct construction shall comply with the requirements of Appendix 5/2.

## HMEP NG 503 BEDDING, LAYING AND SURROUNDING OF PIPES

1. Pipe bedding material should be readily obtainable since a wide range of gradings and sizes complying with BS EN 13242 are permitted. Pipe bedding material needs to flow readily and compact uniformly, thus a low coefficient of uniformity is necessary. In order to make savings in coarser granular materials a sand bed may be adopted. Surround to pipes should be in bedding material or acceptable material (Class 8) as appropriate to the alternatives shown in the HCD. Coarse granular material may consist of natural aggregate, recycled coarse aggregate, recycled concrete aggregate, artificial or blended combinations of these aggregates, which satisfy the requirements of the specification.
2. The limiting values in sub-Clauses 503.4 and 503.5 have been chosen to ensure that problems do not occur due to oxidation of reduced sulphur compounds such as pyrite. Further guidance is given in sub-Clause NG 601.8 and Clause NG 644.
3. A distinction is to be made between the requirements of bedding, haunching and surrounding and those of backfilling. The former comprise all operations of trench fill up to a level 300 mm above the top of the barrel of the pipe. Backfilling constitutes the remaining operations up to ground level in verges and open ground and up to formation or sub-formation level under carriageways. Work above formation level constitutes construction or reinstatement of the pavement (see NG 706).
4. Concrete surround should be used exceptionally, e.g. for protection of pipes against mechanical damage from subsequent operations after construction of the pipeline and where remedial measures due to over excavation are required. Protection of existing pipes where necessary may take the form of a concrete arch or slab above the pipe.

## HMEP CL 504 SR - JOINTING OF PIPES

1. Rigid joints shall mean joints made solid by caulking the sockets, or bolting together flanges integral with the pipes. Flexible joints shall mean joints made with deformable rings or gaskets held between pipe spigots and sockets, sleeves or collars.
2. Joints in surface water drains shall be watertight complying with sub-Clause 3 of this Clause or partly watertight complying with sub-Clause 4 of this Clause as described in Appendix 5/1. Foul drains shall have watertight joints. Filter drains shall have joints complying with sub-Clause 6 of this Clause. Ducts need not have watertight joints unless otherwise described in Appendix 5/2.
3. Watertight joints shall comply with the appropriate British Standards, the manufacturer's instructions and the following:
  - (i) Rigid joints shall be used only where permitted in Appendix 5/1. Spigots and sockets of rigid joints may be caulked with tarred rope yarn or equivalent and the socket completely filled with mortar designation (i) complying with Clause 2404, excluding lime; a fillet of mortar being worked around the socket extending for a length of not less than 50 mm from the face of the socket. Iron pipes with open sockets shall have rigid joints caulked with lead wool or equivalent.
  - (ii) Joints in PVC-U pipes shall not be made with plastic solvent.
  - (iii) Flexible mechanical joints may be used with surface water pipes complying with BS 65.
  - (iv) Joints for cast iron pipes to BS 437 shall comply with BS EN 877.
  - (v) Joints in thermoplastics structured wall pipe shall comply with Clause 518.
4. Partly watertight joints for surface water drains shall be tested in accordance with sub-Clause 509.7 and shall be British Standard joints or non-British Standard joints. Push fit joints shall have a register to ensure that the pipe is fully pushed into the joint.
 

Corrugated steel pipes of lock seam fabrication, not exceeding 900 mm internal diameter, shall be joined in accordance with the manufacturer's instructions. Bolted segmental plate pipe arches or circular pipes, not exceeding 900 mm internal diameter, shall be joined in accordance with sub-Clause 501.6 (iv) and the manufacturer's instructions.
5. Where a concrete bed, cradle, arch or surround is used with rigid pipes having flexible joints, joint filler board complying with Clause 1015 shall be placed in contact with the end of the socket at a pipe joint and shall extend through the full thickness of the concrete in contact with the pipe.

Such joints in the concrete bed, haunch or surround shall be at intervals not exceeding 5 metres except where the spacing of joints in the pipe exceeds 5 metres when they shall be at each pipe joint.

6. Joints in pipes for filter drains shall comply with the appropriate British Standard and with the following:

- (i) Non-porous and unperforated concrete and clay pipes with spigot and socket, rebated or ogee joints shall be laid with unsealed joints and with a gap of 10 mm between the end of the pipe and the inner end of the socket or rebate. The pipes shall be supported with tarred rope yarn or equivalent flexible jointing material within the sockets over the lower third of the circumference so that there are no vertical steps between one pipe and another. Such pipes shall only be used with Type B filter material as described in Clause 505.
- (ii) The ends of perforated, castellated or porous concrete pipes with rebated joints and perforated clay ware pipes with rebated or with flexible sleeve joints shall be pushed tightly together. The width of slots measured along the length of the pipeline formed by jointing castellated pipes shall not exceed 10 mm.
- (iii) Perforated or slotted thermoplastics pipes with spigots and sockets or sleeves may be dry-jointed or jointed as described in sub-Clauses 3 and 4 of this Clause.
- (iv) Other perforated pipes shall be jointed as unperforated pipes of the same material.

7. Joints in pipes for service ducts shall comply with the appropriate British Standard and with the following:

- (i) Pipes for ducts shall be jointed so that no silt, grit, grout or concrete surround is able to enter the duct. Pipes with push-fit joints shall have a register to ensure that the pipe is fully pushed into the joint.
- (ii) Joints in pipes to BS 3506 shall comply with BS EN 1452-1 to 5 as appropriate.

## HMEP NG 504 JOINTING OF PIPES

1. Pipe joints for surface water drains, unlike foul drains, do not always have to be completely watertight. Small amounts of seepage as allowed in sub-Clause 509.7 can be tolerated particularly where pipes are laid in cuttings or below the water table. However, joints in pipes in soils that are predominantly fine sands or coarse silts should have watertight joints to prevent soil particles passing through the joint into the pipe leaving voids on the outside of the pipe.

Where fine sands or coarse silts might be a problem but the more expensive rubber ring flexible joint is unwarranted, consideration can be given to certain proprietary wrap type joints that are available. These may also be specified where root penetration needs to be prevented. Requirements should be given in Appendix 5/1.

2. Most watertight joints will be flexible joints although rigid joints are occasionally used on clay pipes. In and under embankments, or if differential settlement is expected in compressible soils subject to non-uniform loading, then flexible joints and (except for pipes below the water table laid in non-erodible soils) watertight joints should be specified. The maximum length of pipe between flexible joints may have to be limited where considerable movement is expected. The limits of the exclusions should be shown in Appendix 5/1.
3. Culverts are generally considered to be drains but they do not necessarily require watertight joints. Where watertight joints are required for culverts this should be stated in Appendix 5/1.
- 4 Where seepage occurs from surface water pipes it will drain naturally through the pipe bedding materials and may be collected by means of a weep pipe placed at the down stream manhole.

## HMEP CL 505 SR - BACKFILLING OF TRENCHES AND FILTER DRAINS

1. Backfilling shall be undertaken immediately after the required operations preceding it have been completed.
2. Except where otherwise described in Appendix 5/1, trenches other than filter drain trenches shall be backfilled above the pipe surround material described in Clause 503, with Class 1, 2, or 3 general fill material complying with Series 600.
3. Filter drains shall be backfilled as described in Appendix 5/1 with Type A, Type B or Type C filter material which shall consist of natural or recycled coarse aggregate or recycled concrete aggregate complying with BS EN 13242 and the following:
  - (i) for Type A and C, grading requirements for unbound mixtures in accordance with Table 5/5 and BS EN 13285;

- (ii) for Type B, geometrical requirements in accordance with Table 5/5 and BS EN 13242;
- (iii) a resistance to fragmentation in Category LA<sub>50</sub> in accordance with BS EN 13242, clause 5.2 and Table 9;
- (iv) a water-soluble sulphate content of less than 0.38% of sulphate (as SO<sub>3</sub>) when tested in accordance with BS EN 1744-1, clause 10;
- (v) all other requirements in Category NR;
- (vi) be non-plastic when tested in accordance with BS 1377 : Part 2.

Where recycled coarse aggregate or recycled concrete aggregate is used in accordance with this Clause, it shall have been tested in accordance with Clause 710 and shall not contain more than 1% other materials (Class X).

<b>Table 5/5: Grading and geometrical requirements for filter drain material</b>			
	<b>Type A</b>	<b>Type B</b>	<b>Type C</b>
Standard	BS EN 13285	BS EN 13242	BS EN 13285
Size, mm	0/20	20/40	As described in Appendix 5/1
Grading and oversize categories	$G_F$ (with an additional sieve)	$G_C$ 80-20	
Oversize category	$OC_{80}$	-	
Category for tolerances at mid-size sieves	-	$GT_{NR}$ (no requirement)	
Category for maximum fines	$UF_3$	$f_{NR}$ (no requirement)	
Summary grading requirements			
Sieve size, mm	Percentage by mass passing		
80	-	100	As described in Appendix 5/1
63	-	98 – 100	
40	100	80 – 99	
20	80 – 99	0 – 20	
10	50 – 90	0 – 5	

Table 5/5: Grading and geometrical requirements for filter drain material: continued			
Sieve size, mm	Percentage by mass passing		
4	30 – 75	-	As described in Appendix 5/1
2	15 – 60	-	
0.500	0 – 35	-	
0.125	0 – 4	-	
0.063	0 - 3	-	
% in size fraction			
4/10	5 - 35	-	
2/4	5 - 35	-	

Filter materials, when tested in accordance with sub-Clause 509.8 shall have permeability requirements as described in Appendix 5/1.

When Type A material is used with pipes other than porous pipes at least 15% of the material shall be larger than the diameter of hole or larger than 1.2 times the width of slot in the pipe.

4. Material for backfilling trenches and filter drains shall not be deposited within 500 mm, or any other distances described in Appendix 5/1, of concrete, bound materials, other cementitious materials or stabilised capping forming part of the Permanent Works if, when tested in accordance with TRL Report 447 either:
- (i) the water-soluble sulphate (WS) content exceeds 1500 mg of sulphate (as  $\text{SO}_4$ ) per litre (Test No.1); or
  - (ii) the oxidisable sulphate (OS) content exceeds 0.5% of sulphate (as  $\text{SO}_4$ ) (Test No.2 and Test No.4); or
  - (iii) the 2:1 water to soil extract prepared for the determination of water-soluble sulphate in (i) has a pH value of less than 7.2, when tested using the electrometric method of pH determination in accordance with BS 1377-3.

At least five samples of each material shall be tested for WS, OS and pH value. The mean of the highest two values shall be used for comparison with the limiting values. This also applies if six to nine results are available. If ten or more results are available, the mean of the highest 20% of the results shall be used for comparison with the limiting values.

5. Material for backfilling trenches and filter drains shall not be deposited within 500 mm, or any other distances described in Appendix 5/1, of metallic structural elements forming part of the Permanent Works if, when tested in accordance with TRL Report 447 either:
- (i) the water-soluble sulphate (WS) content exceeds 300 mg of sulphate (as SO<sub>4</sub>) per litre (Test No.1); or
  - (ii) the oxidisable sulphate (OS) content exceeds 0.06% of sulphate (as SO<sub>4</sub>) (Test No.2 and Test No.4).

At least five samples of each material shall be tested for WS and OS. The mean of the highest two values shall be used for comparison with the limiting values. This also applies if six to nine results are available. If ten or more results are available, the mean of the highest 20% of the results shall be used for comparison with the limiting values.

The requirements in (i) and (ii) above shall not apply to metallic structural elements protected by concrete and ancillary items such as the tops of chambers and gullies.

6. Backfilling shall be deposited and compacted in compliance with Clause 612. Filter material for filter drains shall be deposited in layers not exceeding 225 mm loose depth; each layer then being compacted in compliance with Table 6/4 Method 3.
7. Material shall be deposited in even layers and shall not be heaped in the trench before being spread. Spreading and compaction shall be carried out evenly without dislodging, distorting or damaging the pipe. Power rammers shall not be used within 300 mm of any part of the pipe or joint.
8. Except in carriageways, other paved areas and locations described in Appendix 5/1, backfill of trenches shall be brought up to ground level. Where topsoil is at the surface on the line of the trench the upper section of the backfill shall be topsoil of the thickness described in Appendix 6/8, or of the same thickness and quality of topsoil as the surrounding ground where no thickness is specified. For trenches in carriageways or other paved areas the backfill shall be brought up to formation level, or sub-formation level where capping is required, unless a lower level is described in Appendix 5/1. Sheeting and other excavation supports shall be removed as the filling proceeds unless otherwise described in Appendix 6/3.
9. The position of service ducts shall be marked when the trenches are backfilled and permanent marker blocks and location posts provided as described in Appendix 5/2.

## HMEP NG 505 BACKFILLING OF TRENCHES AND FILTER DRAINS

1. Type A material is intended for sub-soil drainage. The Specification permits a wide grading envelope from BS EN 13285 so that local sources may be used as far as possible. When soils to be drained require a particular grading of filter aggregate it can be specified under the heading Type C in Table 5/5. The design should be based on knowledge of local sources of supply, BS EN 13285 and Transport and Road Research Laboratory Report LR 346 which gives guidance on the design of filter materials. Type B material is a coarse aggregate complying with BS EN 13242, intended for use where the drain is designed to intercept surface water flowing to the pipe. Grit from the carriageway may slowly block this type of filter and it may require cleaning or replacement periodically. Where filter drains are located close to carriageways and are likely to be overrun by traffic, methods of preventing the problem of 'stone scatter' should be considered. Some possible solutions are shown on HCD Drawing Number B15.
2. The limiting values in sub-Clauses 505.4 and 505.5 have been chosen to ensure that problems do not occur due to oxidation of reduced sulphur compounds such as pyrite. Further guidance is given in sub-Clause NG 601.8 and Clause NG 644.
3. Filter drains can be constructed by machines that excavate the trench, support the sides, and lay the pipe and backfill with filter material in one operation. The trench is normally constructed with a semi-circular floor providing a most effective support to the pipe without further bedding. As contamination of the filter material is minimised by the supporting shutter attached to the machine a much narrower trench than that achieved by conventional excavation is possible.

## HMEP CL 507 SR - CHAMBERS

1. Chambers shall include manholes, catchpits, inspection chambers, draw pits and walled soakaways. Chambers shall be of the type specified in Appendix 5/1, constructed in accordance with HCD Drawing Numbers F3 to F12 and F25 to F27 as appropriate to that type. All ST concrete referred to in this Clause shall comply with Clause 2602, unless otherwise described in Appendix 5/1.
2. Foundations to chambers shall be of ST4 concrete. Channels for chambers shall be formed and finished smooth in the foundation concrete or constructed of preformed half circle channels, with sides benched in ST4 concrete, or mortar designation (i) complying with Clause 2404 excluding lime. Alternatively for inspection chambers not exceeding 1.3 metres in depth to invert, complete plastics units or other units in equivalent material surrounded by 150 mm of ST4 concrete may be used.
3. Brickwork shall comply with Series 2400 and be built with mortar designation (i) in English bond. The joints of brickwork where exposed shall be finished as specified for

unpointed joints in Clause 2412. The ends of all pipes shall be neatly built into the brickwork and finished flush with mortar designation (i).

4. Precast concrete chambers shall comply with BS 5911-3 and BS EN 1917 and the particular requirements described in Appendix 5/1. Cast in-situ concrete chambers shall be constructed of ST4 concrete complying with Clause 2602 and the particular requirements described in Appendix 5/1.
  5. Corrugated galvanized steel chambers shall comply with Clause 501 with insitu ST4 concrete inverts and precast concrete cover slabs complying with BS 5911-3 and BS EN 1917 and the particular requirements described in Appendix 5/1. They shall be surrounded with well graded granular material Class 6M as described in Table 6/1 compacted in accordance with Clause 612.
  6. Where the depth of invert of chambers, excluding inspection chambers, exceeds 900 mm below the finished surface of the carriageway or the adjacent ground, manhole steps complying with BS EN 13101 shall be built in accordance with relevant Series F-HCD Drawings. Steelwork used for ladders, handholds and other fittings shall comply with BS 970 : Part 1 and be galvanized in compliance with Clause 1909 after fabrication. Threaded components shall be galvanized in compliance with Clause 1909.
  7. Excavation around chambers, except those described in sub-Clause 5 of this Clause, shall be backfilled with general fill material as described in Table 6/1 and compacted in compliance with Clause 612. Where mechanical compaction is impracticable, the excavation shall be backfilled with ST2 concrete.
- Where there are precast concrete access shafts to precast concrete chambers, the shafts shall be surrounded by a minimum thickness of 150 mm of ST4 concrete, and the remaining excavation backfilled with general fill material as described in Table 6/1 compacted in compliance with Clause 612.
8. Chambers for foul drains shall be tested for watertightness as and where required in Appendix 5/1.
  9. Chamber covers, gratings and frames shall be as described in Appendix 5/1 and shall comply with BS EN 124 and sub-Clauses 10 and 15 of this Clause. The cover shall be of suitable material, design and construction to achieve an in-service skid/slip resistance potential suitable for the conditions of use. This shall be determined by the accelerated polish test method described in BS 9124. The PSRV shall be as stated in Appendix 5/1.
  10. Class D 400 units and above shall incorporate a permanent non-rock feature either triangular point suspension or machined faces.
  11. Bolts supplied for loosely coupling separate sections of covers and gratings shall be steel hexagon headed, complying with the requirement of BS EN ISO 4016, BS EN ISO 4018 and BS EN ISO 4034 and be galvanized in compliance with Clause 1909.

They shall not be less than size M16 complete with hexagon nut and shall be provided with means to prevent undue tightening of unit sections.

12. Unless otherwise specified in Appendix 5/1, all covers, gratings and frames shall be supplied in a fine cast (uncoated) condition. Where a coating is specified in Appendix 5/1, the coating shall only be applied when the surfaces of the casting are clean, free from rust and dry.
13. Requirements for special duty covers for use in carriageways shall be as described in Appendix 5/1.
14. Gratings for catchpit chambers shall have a minimum waterway area as described in Appendix 5/1.
15. Two sets of lifting keys shall be delivered to the Overseeing Organisation for each type of cover supplied. At least two keyways, as detailed on HCD Drawing No. F17, shall be provided in each complete cover, one in each segment for segmental covers. A recess for a prising bar shall be incorporated in manhole covers unless other means of loosening the cover from the frame are provided.
16. Frames for chamber covers and gratings located in carriageways or vehicle accesses shall be set in a proprietary resin-based mortar complying with the following properties:

Property	Test Method	Value
Tensile Strength	BS 6319: Part 7	5 N/mm <sup>2</sup> minimum at 3 hours
Compressive Strength	BS 6319: Part 2	30 N/mm <sup>2</sup> minimum at 3 hours
Shrinkage	-	Material to be non-shrink
Workability Slump	-	Less than 50 mm
Working Life	-	Minimum of 15 minutes

In all cases the cover and frame shall not be exposed to any load or disturbance until the bedding material has attained a strength of 20 N/mm<sup>2</sup>.

Where no vehicular loading will take place frames for chamber covers and gratings, including soakaway covers, may be bedded on mortar designation (i) complying with Clause 2404, or as specified by the Overseeing Organisation in Appendix 5/1.

17. For all pipelines except those constructed with corrugated pipes the nearest joint to any chamber shall be not more than 500 mm from the inner face of the wall and shall not be restricted by any concrete. Between this and the next joint, the length of the articulated pipe shall be in accordance with Table 5/6.

<b>Nominal Pipe Diameter (mm)</b>	<b>Length of Pipe (mm)</b>
450 and less	500 to 750
Greater than 450	750 to 1000

18. Where the adjustment or replacement of existing frames and covers or gratings is required, the units shall be taken up and re-fixed or removed and replaced with new units complying with sub-Clauses 9 to 15 of this Clause, or as described in Appendix 5/1. On taking up or removal of the unit, any concrete or mortar bedding shall be broken out and the surface prepared. Where existing frames and covers or gratings are to be adjusted, the Contractor shall take up the unit and clean it for re-use.

The adjusted or replaced units shall be laid on a mortar bed complying with sub-Clause 16 of this Clause. The finished thickness of the mortar bed shall be between 10 mm and 25 mm. Where required in Appendix 5/1, covers and gratings shall be bedded using a proprietary quick setting high strength mortar. Details of such mortar shall be to the approval of the Overseeing Organisation. Unless otherwise described in Appendix 5/1, adjusted or replaced frames and covers or gratings shall be set flush with the new surface. Any additional adjustments shall be by modifying the brickwork in compliance with sub-Clause 507.3 or by using a frame of a suitable depth. On completion of the works, each cover shall be lifted and the frame and seating cleaned.

### **HMEP NG 507 CHAMBERS**

- Concrete chambers, precast or cast insitu against forms, do not require strengthening with additional concrete surround. Access shafts in precast concrete should be strengthened, however, as a protection against loads from backfilling operations. Brick chambers, including shafts do not need a concrete surround for strengthening. It may however be necessary to backfill with concrete where space is insufficient to permit compaction of one of the earthwork's acceptable materials. Inspection chambers are those that can be maintained from the surface and do not need to be entered.

The types of brick to be used for brick chambers, and beneath chamber frames, in normal circumstances are specified in Clause 2406.

Where a different type of brick is required this should be described in Appendix 24/1.

Any brickwork upon which chamber frames are seated should be properly constructed.

2. Safety precautions require that chamber covers have a minimum opening as shown on the HCD Drawings where personnel may be required to enter completely. In carriageways, hard shoulders and verges, chamber covers, frames and gratings should be at least Class D400. Where site conditions necessitate, covers having to be located in areas subjected to large numbers of high speed heavy goods vehicles, Class E600 chamber covers, frames and gratings should be considered. Advice may be sought from the Overseeing Organisation. It will normally be expected that the minimum frame depth is 150 mm. When specifying cover types, Compilers should have regard to the weight of each element of the cover so that it could be lifted safely and should review the measures available to prevent covers falling into the chamber when being removed. Reference should be made to the HSE Manual Handling Operations Regulations 1992 guide 'Guidance on Regulations L/23 1998', where appropriate.
3. It may be necessary, due to constraints in pipe lengths to vary the lengths of the articulated section described in sub-Clause 507.17. However, the principle of having the joint nearest the chamber as close as possible to the chamber and the next joint positioned so as to give an effective length of intervening articulated pipe, free from constraint by the trench bottom, should be maintained.
4. BS EN 124 makes no reference to coatings. Many manufacturers apply a coating in order to prevent discolouration of the castings while in stock or in transit. However, BS 7903 : 1997 states that short term coatings offer no lasting product enhancement and any surface oxidation of the cast iron has no detrimental effect upon its use.
5. It is essential that the in-service skid resistance of a cover is suitable for the conditions of use. The site categories given in HD 28 (DMRB 7.3.1) should be used as guidance.

To convert the SCRIM Coefficient (SC) figures given in HD 28 to the Polished Skid Resistance Value (PSRV) given in BS 9124 the following formula can be used.

$$\text{PSRV} = (\text{SC} + 0.05) \times 100$$

It is important to note that the skid resistance of the cover in use will depend upon a number of factors. These factors might include the material from which the cover is made, the type of pattern on the surface of the cover in use, the type of trafficking that the cover is subjected to, environmental conditions etc.

The actual skid resistance of the cover in use at any point in time is likely to be different from that obtained on the cover at the point of manufacture or installation.

Where a specified level of skid resistance in use is required then it is important that a cover is selected that can withstand the trafficking expected at a particular site so that the level of polishing does not reduce the frictional properties of the cover to a level below that required.

The Unpolished Skid Resistance Value (USRV) and/or the use of a pattern on the surface of the cover does not in itself ensure satisfactory levels of skid resistance for all situations of use.

## HMEP CL 508 SR - GULLIES AND PIPE JUNCTIONS

1. Gullies shall be trapped, untrapped or sumpless as described in Appendix 5/1 and be in accordance with HCD Drawing Numbers F13 and F14. All ST concrete referred to in this Clause shall comply with Clause 2602 unless otherwise described in Appendix 5/1.
2. Gullies shall be constructed so that no part of the spout or trap has a cross-sectional area less than  $2/3^{\text{rd}}$  that of the outlet. The depth of water seal in trapped gullies shall be not less than 50 mm.
3. Precast concrete gullies shall comply with BS 5911-6 and clay gullies with BS EN 295. Insitu concrete gullies shall be as described in Appendix 5/1 and constructed of ST4 concrete of 150 mm minimum thickness, using permanent or removable shuttering. Where insitu concrete gullies are formed with permanent shuttering, such shuttering shall have a current British Board of Agrément Roads and Bridges Certificate.
4. Gully gratings, kerb type gully covers and frames shall comply with BS EN 124 and the following and shall be of the classes and sizes described in Appendix 5/1.
5. The upper surface of gully gratings shall be flat except where otherwise described in Appendix 5/1. Slots in gratings or between gratings and frames shall not be orientated parallel to the direction of traffic except where the slots are less than 150 mm long or less than 20 mm wide. Minimum waterway areas shall be as specified in Appendix 5/1.

Unless otherwise specified in Appendix 5/1, all gratings and frames shall be supplied in a fine cast (uncoated) condition. Where a coating is specified in Appendix 5/1, the coating shall only be applied when the surfaces of the casting are clean, free from rust and dry. Frames shall be bedded on mortar complying with sub-Clause 507.16. Brickwork shall comply with sub-Clause 507.3.

6. Backfilling to precast gullies shall be carried out up to sub-formation level with general fill material Class 1, as described in Table 6/1 compacted in compliance with Clause 612. Where mechanical compaction is impracticable, the backfilling shall be in ST2 concrete. The remainder of the backfilling shall be in appropriate capping and road pavement materials except that where mechanical compaction of capping or unbound mixture for sub base is impracticable ST2 concrete shall be used.
7. Gully connection pipes shall be either flexible or rigid not exceeding 0.7 m in length with flexible joints for a distance of 2 m from the gully and shall be in accordance with sub-Clause 507.17 when entering chambers. Junction pipes shall be manufactured of

the same type and class of material as the remainder of the pipes in the run. Junction pipes which are laid but not immediately connected, shall be fitted with temporary stoppers or seals and the position of all such junctions shall be clearly defined by means of stakes or tracing wires properly marked or labelled. Saddles may be used to form junctions only where permitted in Appendix 5/1. No internal projections greater than 5 mm will be permitted. Saddles for asbestos cement and plastic pipes shall be installed in accordance with the manufacturer's recommendations. Saddles with clay pipes shall be jointed with mortar designation (i) complying with Clause 2404, excluding lime. Saddles and pipes shall be surrounded with ST2 concrete.

8. Where the adjustment or replacement of existing frames and gratings is required, the units shall be taken up and re-fixed or removed and replaced with new units complying with sub-Clauses 4 and 5 of this Clause, or as described in Appendix 5/1. On taking up or removal of the unit, any concrete or mortar bedding shall be broken out and the surface prepared. Where existing frames and covers or gratings are to be adjusted, the Contractor shall take up the unit and clean it for re-use. The adjusted or replaced units shall be laid at a level, unless otherwise described in Appendix 5/1, 6 mm below the adjoining road surface on a mortar bed complying with sub-Clause 507.16. The finished thickness of the mortar bed shall be between 10 mm and 25 mm.

Where required in Appendix 5/1, covers and gratings shall be bedded using a proprietary quick setting high strength mortar. Details of such mortar shall be to the approval of the Overseeing Organisation.

9. Any additional adjustment shall be made by modifying the brickwork in compliance with sub-Clause 507.3 or by using a frame of suitable depth. On completion of the works, each grating shall be lifted and the frame and seating cleaned.

### HMEP NG 508 GULLIES AND PIPE JUNCTIONS

1. Trapped gullies are essential only on connections to combined or foul drains in urban areas or on roads where traps are regularly and frequently emptied. In terms of pollution there is little difference in water quality between the flow through trapped or untrapped gullies although a trapped gully would normally retain the contents of a vehicle's sump in the event of an accident. Further advice on sumpless gullies can be found in HA 105 (DMRB 4.2.3).
2. Where concrete trapped gullies are cast insitu using a permanent plastic mould, the part forming the trap should be equal in all respects to that of precast concrete or clay gullies.
3. Any brickwork upon which gully frames are seated should be properly constructed.

## HMEP CL 509 SR - TESTING AND CLEANING

1. Drains required in Appendix 5/1 to have watertight joints shall be tested as described in Appendix 1/5 in sections, e.g. between chambers, by means of the air test described in sub-Clause 2 of this Clause.

If a pipeline is rejected because of a failed air test, as part of the rectification work, a water test as described in sub- Clause 3 of this Clause may be carried out as an alternative acceptability test. Before testing, the ends of the pipeline to be tested, including those of short branches, shall be plugged and sealed.

2. For the pipeline air test, air shall be pumped in by suitable means until a stable pressure of 100 mm head of water is indicated in a U-tube connected to the system.

The air pressure shall not fall to less than 75 mm head of water during a period of 5 minutes without further pumping, after an initial period to allow stabilization. Drains with traps shall be tested to 50 mm head of water and the permissible loss shall then be no more than 13 mm head of water in 5 minutes without further pumping after the initial stabilising period.

- 3 For the pipeline water test, the pipes shall be filled with water under a head of not less than 1.2 m above the crown of the pipe at the high end and not more than 6 m above the pipe at the low end. Steeply graded pipelines shall be tested in sections so that the above maximum is not exceeded.

The test shall commence not less than two hours after filling the test section at which time the level of water at the vertical feed pipe shall be made up to produce the required 1.2 m minimum test head. The loss of water over a 30 minute period shall be measured by adding water at regular 10 minute intervals to restore the original water level and recording the amounts so added. The drain will have passed the test if the volume of water added does not exceed one litre per hour per linear metre of drain per metre of nominal internal diameter.

4. All pipelines less than 350 mm diameter, excluding service ducts shall be checked by drawing through each completed length of pipe a spherical mandrel of a diameter 10% less than the nominal bore of the pipes being tested.
5. During the progress of the Works all existing chambers, gullies and rodding eyes shall be kept clean and free from obstruction. On completion of the whole of the Works, all chambers, gullies and drains including verge/surface water drains and filter drains but excluding all fin and narrow filter drains shall be flushed from end to end with water and left free from obstructions. Catchpit chambers shall be left clean and free from silt.

Unless otherwise required in Appendix 90/1 - Manual of Contract Documents for Highway Works 5.9.3 all carrier, foul and filter drains but excluding all fin and narrow filter drains shall be surveyed by Closed Circuit Television (CCTV) in accordance with the relevant requirements of Series 9000 (Manual of Contract Documents for Highway

Works 5.9, Parts 1 to 5). Further guidance is provided in sub-Clauses NG 509.3 to NG 509.6.

6. The pipes and filter material of filter drains shall at all times be left clean and free from silt and obstruction.
7. Where described in Appendix 1/5, samples of one or more partly watertight joints for pipelines up to and including 900 mm diameter shall be tested with a head of water kept level with the crown of the pipe. The joint will not be accepted if the flow through the joint in litres per minute exceeds 20 times the square of the nominal internal diameter of the pipe in metres.
8. Permeability tests shall be as described in Appendix 5/1.
9. Service ducts shall be checked by drawing a wooden mandrel, as shown on HCD Drawing Number I2, through as the ducts are laid but where a set has to be given to the line of ducts the wooden mandrel shall be replaced by an iron mandrel 250 mm long but of the same diameter as the wooden version.
10. Air / Water Testing of pipes should be carried out following backfill of the run and construction of chambers.

## HMEP NG 509 TESTING AND CLEANING

1. Requirements for drain testing should be specified in Appendix 1/5. The air test does not indicate the location of any large leaks that may be present. A water test may follow the failure of an air test.
2. Fall of the test water level may be due to one or more of the following causes:
  - (i) Absorption by pipes or joints.
  - (ii) Excessive sweating of pipes or joints.
  - (iii) Leakage from defective pipes or joints or plugs.
  - (iv) Trapped air.

Some pipes absorb more water or trap more air at the joints than others. Allowance should be made for this by adding water to maintain the test head for appropriate periods. While the aim should be to commence the test period proper 2 hours after filling, the appropriate period may best be determined by conferring with the pipe manufacturers.

3. When checking pipelines, Closed Circuit Television (CCTV) inspection is a suitable alternative to the mandrel test. However, CCTV inspection should always be used on foul sewers and connections to sewers as the consequences of raw sewage pollution are considerably more significant. To avoid subsequent disputes it is essential to liaise with the drainage authority when checking connections to existing sewers to ensure acceptability of the work and to determine the extent of the survey required on existing sewers.
4. The test for partly watertight joints must be carried out before the pipe is laid because the water escaping from the joint has to be measured. The purpose of the test is to prove that the joint does not leak so excessively as to cause piping in any granular surround.
5. Series 9000 Manual of Contract Documents for Highway Works 5.9, Parts 1 to 5 contains the documentation for the specialist activity of the CCTV survey of highway drainage systems. The specification covers all types of pipes with diameters up to and including 900 mm including sub-surface drainage and other non-piped systems that are being introduced. Pipes and conduits in excess of 900 mm are classified as structures that require technical approval; however, this technique is equally applicable to the remote inspection of these structures up to 1800 mm diameter.
6. When checking foul drains and their connections to existing sewers, it is essential to liaise with the drainage authority to ensure acceptability of the Work and to determine the extent of the survey, including CCTV survey, required.

## HMEP CL 510 SR - SURFACE WATER CHANNELS AND DRAINAGE CHANNEL BLOCKS

1. Surface water channels and drainage channel blocks shall be constructed as described in Appendix 5/3.
2. Surface water channels shall comply with Clause 1103.
3. Drainage channel blocks shall comply with Clause 1101.

## HMEP NG 510 SURFACE WATER CHANNELS AND DRAINAGE CHANNEL BLOCKS

1. Requirements for these should be included in Appendix 5/3 and be compatible with the relevant HCD Series B and Series F drawings.

## HMEP CL 511 SR - LAND DRAINS

1. Existing land drains which are permanently severed by the Works shall be located and connected into a new drain, pipe or ditch all as described in Appendix 5/1. The lengths remaining within the Works shall be cleaned out from the new drain trench face as necessary. Any pipe disturbed by the Works shall be re-laid to ensure a free discharge into the new drain. Disused ends of intercepted land drains shall be adequately sealed with ST2 concrete in compliance with Clause 2602.
2. Where an existing land drain is exposed and severed by temporary trench excavation, the Contractor shall mark the position of the drain and record it. The drain shall be diverted into an existing drain or watercourse. Alternatively, the normal functioning of the drain shall be continued by the construction of a pipeline or channel adequately supported across the excavation, until permanent restoration is made on the original line.
3. The Contractor shall notify the Overseeing Organisation of any land drain which is blocked or is otherwise defective when the drain is first exposed.
4. Severed mole drains shall be led straight into new drains; alternatively they shall where required in Appendix 5/1 be intercepted by the construction of a land drain. Where they have been disturbed mole channels shall be cleaned out and filled locally with Type A filter material or as otherwise described in Appendix 5/1.

### HMEP NG 511 LAND DRAINS

1. The Works are likely to disturb and render ineffective existing drainage systems in adjoining land; it will therefore be necessary for the Contractor to carry out without delay any such temporary or permanent remedial works as may be described in Appendix 5/1. The ideal arrangement for land drainage remedial works is that the system of drainage of land adjoining the road should be separate from the road drainage so that the reinstatement of the system is on the owner's land and the matter is dealt with by the District Valuer as a matter of accommodation works. When such arrangements are not practicable or the cost is excessive, the existing land drainage system should be linked with the drainage system of the road.

### HMEP CL 512 SR - BACKFILLING TO PIPE BAYS AND VERGES ON BRIDGES

1. Unless otherwise described in Appendix 5/1, filling to pipe bays and verges on bridges shall be well graded granular material not exceeding 20 mm size containing not more than 3% of material passing the 0.063 mm sieve and with a uniformity coefficient of more than 5. It shall be laid and compacted in compliance with sub-Clause 505.6 and 7. The material shall meet the sulphate requirement described in sub-Clauses 503.4, 503.5, 505.4 and 505.5.

### HMEP NG 512 BACKFILLING TO PIPE BAYS AND VERGES ON BRIDGES

1. Any special filling material, e.g. lightweight material, should be described by providing additional information on the drawings, cross-referenced in Appendix 5/1.

### HMEP CL 513 SR - PERMEABLE BACKING TO EARTH RETAINING STRUCTURES

1. Unless otherwise described in Appendix 5/1, permeable backing shall consist of one of the following materials except when the filling adjacent to the structure is selected cohesive material (Class 7A), selected conditioned pulverised-fuel ash (Class 7B) or chalk:
  - (i) A minimum thickness of 300 mm of granular material complying with the requirements of Clause 505 for Type A or Type C material and, in addition, satisfying the following criteria:

Piping ratio, defined as

$$\frac{15 \text{ per cent size of the drainage material,}}{85 \text{ per cent size of the backfill material}} <5$$

Permeability ratio, defined as

$$\frac{15 \text{ per cent size of the drainage material,}}{15 \text{ per cent size of the backfill material}} >5$$

where the per cent size of a material is the size of particle corresponding to the given per cent ordinate of the particle size distribution graph.

- (ii) Porous no-fines concrete, cast insitu 225 mm thick complying with the requirements of Clause 2603.
  - (iii) Precast hollow concrete blocks complying with the BS EN 771-3 laid in stretcher bond with dry joints in 225 mm thick walling with holes vertical.
2. When the filling adjacent to the structure is selected cohesive material (Class 7A), selected conditioned pulverised-fuel ash (Class 7B) or chalk, the permeable backing shall be a minimum thickness of 300 mm of 0/4 or 0/2, CP or MP, sand complying with BS EN 12620 unless otherwise described in Appendix 5/1.

### HMEP NG 513 PERMEABLE BACKING TO EARTH RETAINING STRUCTURES

1. For granular backing, Type C has been added to allow for the design of a filter material compatible with the particular type of filling to be employed adjacent to the structure. It is recognised that the use of Type A will not always meet the piping and permeability ratio criteria.
2. Fin drains are not allowed as permeable backing to structures because it is not yet possible to demonstrate that any of them will have the required design life of 120 years.

### HMEP CL 514 SR - FIN DRAINS

#### General

1. Fin drains shall comply with this Clause and the special requirements described in Appendix 5/4.

The terms thickness, width, height and core shall have the meanings indicated on HCD Drawing Number F18 unless otherwise described in Appendix 5/4.

The term fin drain shall mean a planar geocomposite structure designed to perform the same function as a narrow filter drain.

2. Where fin drains are designed for lateral entry of water from one side only the requirements for flow rates in sub-Clauses 4 and 5 of this Clause shall apply to the face or plane designed to admit or transmit water.
3. The materials of which the drain is made shall be treated so that they are protected from the deleterious effects of short term exposure to ultraviolet light, and shall be resistant to degradation by acids, alkalis, common chemicals, bacteria, fungi and moulds occurring in soils and highway construction materials. After exposure to ultraviolet light the Overseeing Organisation may require evidence that the materials still comply with the requirements of this Clause. The drain shall be protected from damage and ultraviolet light and be labelled to identify the grade and manufacturer or supplier. Where necessary, the side intended for entry of water and the direction of in-plane flow shall be identified.

### Geotextile

4. The geotextile shall:
  - (i) in both machine and cross-machine directions, sustain a tensile load of not less than 5.0 kN/m at break and have a minimum failure strain of 10% when determined in accordance with BS EN ISO 10319;
  - (ii) have a minimum puncture resistance of 1200 N when determined in accordance with BS EN ISO 12236;
  - (iii) have a minimum tear resistance of 200 N when determined in accordance with ASTM Standard D4533-91(1996);
  - (iv) have a size distribution of pore openings such that the apparent opening size O90 when determined in accordance with BS 6906 : Part 2, or other appropriate test, is as stated in Appendix 5/4;
  - (v) allow water to flow through it, in either direction, normal to its principal plane at a rate of not less than that stated in Appendix 5/4 under a constant head of water of 100 mm and a maximum breakthrough head of 50 mm when determined in accordance with BS 6906 : Part 3.

### Composite Drain

5. The composite drain shall:
  - (i) have a flow rate through each face of the drain of more than 75% of the value specified in sub-Clause 4(v) of this Clause on the side or sides where inflow occurs. This value may be found by either:
    - (a) direct measurement of the composite drain using a modified version of BS 6906 : Part 3; or

- (b) calculation based on the flow rate obtained by the standard test in BS 6906 : Part 3 and the percentage contact area of the drainage core obtained from sub-Clause 13 of this Clause or other appropriate method;
- (ii) have values of long term in-plane flow rates as stated in Appendix 5/4 when determined in accordance with sub-Clauses 14 and 15 of this Clause. The values of hydraulic gradient and minimum applied stresses shall be as given in Table 5/7.

TABLE 5/7: Applied Stresses (kN/m <sup>2</sup> ) and Hydraulic Gradient					
HCD Drain Type	5	6	7	10	
Sub-Clause 14:					
Normal Stress	50	50	50	100	
Shear Stress	10	10	10	10	
Sub-Clause 15:					
Normal Stress	100	100	100	100	
Sub-Clause 15:					
Hydraulic Gradient	0.1 1.0	1.0	1.0	0.1 1.0	

## Joints

6. Fin drains shall be capable of being jointed longitudinally or laterally into pipe systems or chambers for inflow and outflow purposes and be self jointing either directly or through purpose made attachment pieces for forming continuous drain lengths. All such joints shall be formed so as to prevent the ingress of soil particles or other extraneous material into the drain.

Fin drain joints transverse to the direction of flow shall have values of in-plane flow rates not less than that required by sub-Clause 5(ii) of this Clause.

Fin drain joints parallel to the direction of flow and any exposed edges shall be protected from the ingress of soil by a geotextile wrapping with a minimum overlap of 150 mm.

## Pipes

7. For drain Type 6 pipes shall be perforated or porous and comply with sub-Clause 501.3. Pipes complying with BS 4962 : 1989 shall have a minimum Ultimate Pipe Stiffness (STES) value of 1400 N/m<sup>2</sup>.

For drain Type 7 pipes shall be unperforated thermoplastics pipe complying with BS 4660, BS 5481, BS EN 1401, BS EN 1852-1 or BS EN 12666-1 slotted longitudinally along the top surface and stress relief treated (if required) in accordance with the system manufacturer's published specification.

8. Pipe joints shall comply with the requirements of the relevant British Standard for the pipe used or Clause 518.

## Backfill and Surround Material

9. Pipe surround material for drain Types 6 and 7 shall comply with sub-Clause 503.3(i) or 503.3(ii) or Type A or C material complying with sub-Clause 505.3.

Where fin drains are installed in a trench backfill material shall be the original as-dug material from the trench unless otherwise specified in Appendix 5/4.

## Dimensions

10. Unless otherwise described in Appendix 5/4 the dimensions of the fin drain shall be as shown on HCD Drawings F18 to F21. The pipe diameter shall be as stated in Appendix 5/4. The drain slope angle ( $\alpha$ ), as shown on Drawing F19, shall be not greater than 15% from the vertical unless otherwise stated in Appendix 5/4.

## Installation and Handling

11. Installation of fin drains shall be as shown on HCD Drawing Numbers F19 to F21. Where fin drains are assembled on site the assembly area shall be clean and dry and free of wind-borne pollutants. Any material which becomes contaminated must be replaced. No geotextile or core material shall be exposed to daylight (or any source of ultraviolet radiation) for a period exceeding a cumulative total of 50 hours. Any geotextile or core material exposed to daylight (or any source of ultraviolet light) for a period exceeding a cumulative total of 50 hours shall be replaced unless it can be demonstrated that the materials of the drain still comply with the requirements of this Clause.

Where fin drains are laid in trench, the trench bottom shall be free of irregularities and to the required levels given in Appendix 5/4. Rock and other hard protuberances shall be removed and any excess cut in the trench bottom filled and compacted back to the required grade with suitable excavated or imported material.

The drain shall be laid with the appropriate face against the side of the trench adjacent to the carriageway and in the appropriate direction. This side of the trench shall have walls sufficiently clean to enable the fin drain to come into close contact with the wall when the trench is backfilled and compacted. Compaction shall be in accordance with

Clause 612. Fin drains installed as part of the Permanent Works shall be protected from surface water, contamination, and accidental damage during construction.

The fin drain, pipe surround and backfill shall be installed so as to cause no damage to the fin drain. Where any damage does occur, the damaged materials shall be replaced by new material.

After the installation of the fin drain has been completed a marker tape shall be laid approximately 75 mm above the fin drain in the position shown on HCD Drawing Numbers F19 and F20. The tapes shall be green self-coloured PVC or polythene plastic not less than 0.1 mm thick and 150 mm wide.

### Identification

12. The Contractor shall obtain and make available the following information for each separate consignment of fin drain delivered to Site:
- (i) geotextile and core name, grade/number and mass per unit area;
  - (ii) names and addresses of system producer, and geotextile, core and pipe manufacturers;
  - (iii) manufacturing characteristics and constituents of geotextile and core. This shall include composition and type of constituent filaments, threads, fibres, films, tapes and other components;
  - (iv) consignment number and delivery date;
  - (v) a copy of the site delivery note.

### Test Method for the Percentage Contact Area of Drainage Core

13. (i) The test determines the area of one face of a drainage core which will be in contact with a geotextile filter as a percentage.
- (ii) The apparatus required is as follows:
- (a) loading device able to apply a compressive load of at least 2 kN and having a flat steel base;
  - (b) flat steel loading plate 200 mm x 200 mm;
  - (c) printers ink and roller (or pad);
  - (d) sheet of thin compressible rubber;
  - (e) planimeter.
- (iii) The test procedure shall be as follows. Cut three representative test specimens 200 mm x 200 mm ( $\pm 2$  mm). Apply ink to one 200 mm x 200 mm face of a specimen and cover with a sheet of plain paper and a thin

compressible rubber sheet. Place the prepared specimen in to the loading device and gradually apply the load of 2 kN and maintain for 5 minutes. Release the load and remove the specimen and separate it from the paper. Using the planimeter find the total area of the paper which has received an imprint. Repeat for all specimens.

- (iv) The percentage contact area =

$$\frac{\text{total area of imprint}}{\text{area of test specimen}} \times 100$$

- (v) The report shall include:

- (a) a reference to this method;
- (b) sample identification details;
- (c) individual and mean percentage contact areas;
- (d) details of any deviation from the specified test procedure.

- (vi) Alternative methods of determining the percentage contact area may be employed with the prior approval of the Overseeing Organisation.

#### **Test Method for Determining the Thickness of Fin Drains Under Specified Normal and Shear Stresses**

14. (i) The test determines the thickness of the fin drain under sustained normal and shear stresses. A long term thickness (at 100,000 hours) is calculated by extrapolation and a short term equivalent normal load which produces the long term thickness is determined.
- (ii) The apparatus required is as follows:
- (a) a suitable compression testing machine, which shall have a vertical travel at least the nominal thickness of the specimen. It shall be capable of sustaining the necessary loads to within 1% accuracy for the duration of the test;
  - (b) the compression testing apparatus, which shall include a fixed base plate and parallel moveable top plate with flat steel surface with sufficient friction to permit the development of the required shear forces;
  - (c) a means of measuring the mean thickness of the specimen to an accuracy of 0.01 mm.

As an alternative to (a) and (b), an appropriate inclined plane and kentledge system may be employed to produce the normal and shear loads.

The test procedure shall be as follows:

- (iii) Cut six representative specimens of minimum size 100 mm x 100 mm symmetrically about the core design. Three specimens shall be tested in accordance with (v) below and three in accordance with (vi) below.
- (iv) The test specimen shall be placed symmetrically on the base plate and covered by the top plate. The means of measuring thickness shall be attached and the initial thickness measured.
- (v) Apply the load smoothly and as quickly as possible to the top plate. The full load (normal and shear) shall be applied in less than 20 seconds and sustained for at least 1000 hours. The applied stresses shall be those given in Table 5/7. At least four measurements of thickness shall be made during each unit of logarithmic time after the first minute. Determine the long term thickness of the specimen as the thickness of the specimen at 1000 hours reduced by  $2T$  where  $T$  is the difference in thicknesses of the specimen thickness recorded at 100 hours and 1000 hours. Repeat the test on the two other specimens. The test specimens shall be maintained at a constant temperature of  $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$  throughout the test period.
- (vi) Apply increasing increments of normal load to the specimen. Determine the short term equivalent load which shall be the load which when applied for a period of  $20 \pm 5$  minutes produces a specimen thickness equal (within an accuracy of  $\pm 0.05$  mm) to the long term thickness of the specimen obtained at (v) above. Repeat the test on the other two specimens.
- (vii) The report shall include:
  - (a) a reference to this method;
  - (b) sample identification details;
  - (c) the initial thickness of the sample;
  - (d) the applied load;
  - (e) the thickness of each sample at 100 and 1000 hours and the mean of the three results;
  - (f) a plot of percentage reduction in thickness against logarithmic time;
  - (g) the mean long term thickness;
  - (h) the mean short term equivalent load;
  - (i) any deviations from the specified test procedure.

### Determining In-plane Flow Under Compressive Loading

15. In-plane flow shall be determined in accordance with BS 6906 : Part 7 except that the following conditions shall apply:
- (a) the applied normal stress shall be the greater of the value given in Table 5/7 (for sub-Clause 15) or the mean short term equivalent stress as determined in sub-Clause 14 (vi) of this Clause;
  - (b) the sample shall be tested such that the measured flow (or flows) is in the same direction as the principal flow (or flows) when the fin drain is in service;
  - (c) the foam rubber option of the test procedure shall be used (details of the foam rubber to be used may be obtained from the Overseeing Organisation);
  - (d) the hydraulic transmissivity shall be reported for each of the hydraulic gradients employed.

### Test Methods

16. Notwithstanding the requirements of sub-Clauses 13, 14 and 15 of this Clause, variations in the test methods specified therein shall be made where deemed necessary by the British Board of Agrément following consultation with the manufacturer. All such variations shall be recorded in the report.

### Certification

17. Fin drains and constituent materials shall have a current British Board of Agrément Roads and Bridges Certificate certifying the appropriate physical properties when tested in accordance with this Clause.

### HMEP NG 514 FIN DRAINS

1. These consist of a core which will allow the free drainage of water entering through geotextile filters on the outside of the core. The core may consist of nets, webs, grids or preformed plastic sheets or strips. Some restrict entry through one side or confine water entering to part of the cross-sectional area of the core. Any such restrictions should be taken into account in assessing the flow characteristics of the drain. Fin drains are intended to be used for subsurface drainage, as shown in the HCD, to remove and keep out water from the road structure. They are provided to remove surface infiltration from the pavement layers, to prevent infiltration from shoulders, medians and verges into the pavement, and sometimes to cut off shallow groundwater seepage. They thus act as low-capacity filter drains. In normal circumstances, the Contractor should be permitted the choice of any of the types shown in the HCD. If

however, for engineering reasons, exclusion of a particular type is required, this should be stated in Appendix 5/4. The minimum values for mechanical and hydraulic properties given in Clause 514 are intended for this particular usage and may not be relevant to fin drains used elsewhere. Additionally, the Clause requires specification of the pore size distribution of the geotextile and the inflow and discharge capacity of the fin drain determined for the site conditions.

- The pore size for the geotextile should be selected using filtration criteria to be compatible with the adjacent soil or construction layer in order to prevent the occurrence of piping. The following soil retention criteria may be used in determining O<sub>90</sub>. Other criteria are available.

Uniformity Coefficient of d <sub>60</sub> / D <sub>10</sub> Soil	Woven and Meltbonded Geotextiles	Needle-punched Geotextiles
1 to 5	O <sub>90</sub> /d <sub>50</sub> = 1 To O <sub>90</sub> /d <sub>50</sub> = 3	O <sub>90</sub> /d <sub>50</sub> = 4 to O <sub>90</sub> /d <sub>50</sub> = 6
> 5	O <sub>90</sub> /d <sub>90</sub> < 1 or O <sub>90</sub> /d <sub>50</sub> < 3	O <sub>90</sub> /d <sub>90</sub> < 1.8 or O <sub>90</sub> /d <sub>50</sub> < 6

dn = n% size in base soil (n% is finer)

O<sub>90</sub> = 90% opening (pore) size of geotextile

(90% of openings are smaller)

In general, it will be sufficient to specify only the maximum value of O<sub>90</sub> that will satisfactorily retain the adjacent soil particles as the minimum O<sub>90</sub> size will be governed by the permeability requirements in sub-Clause 514.4. Geotextiles will usually be in contact with variable surface soil deposits, as well as the more uniform materials composing the pavement, and great accuracy in specification may not therefore be feasible. The finest O<sub>90</sub> relevant to the various soil deposits likely to be encountered may be specified. An O<sub>90</sub> value of 1 mm should be considered as the upper limit even with large grained soils. With cohesive fine grained soils such as clays the use of the above criteria will result in such small pore sizes that sufficient water flow cannot be obtained. In such cases the cohesion of the soil particles themselves is relied upon to prevent piping and a maximum O<sub>90</sub> value of 250 microns may be chosen. Dispersive silts can present particular problems and in these cases the O<sub>90</sub> value may be less than 250 microns: however, the value to be specified should be carefully considered in order both to avoid piping and to ensure sufficient long-term flow.

The British Standard test to determine pore sizes (sub-Clause 514.4) is inappropriate for some geotextiles, such as needle-punched materials, if more than 20% of the glass beads are retained in the fabric. Pore sizes must then be obtained by other means such as wet sieving.

3. Sub-Clause 4(v) of Clause 514 requires the designer to specify the flow rate normal to the geotextile wrapping to the filter drain. The specified flow rate should incorporate a margin of safety to allow for the impeded flow due to the adjacent core of the fin drain (or the filter material in a narrow filter drain) as described in sub-Clause 13 of Clause 514. It should also incorporate a substantial margin to allow for the reduction of flow with time due to clogging. The long-term flow through a geotextile in contact with the coarse gravel may not differ significantly from the short-term flow measured in the standard test. In contrast, the long-term flow through a geotextile in contact with a dispersive silt may be one thousand times smaller than the short-term flow. There is some evidence that chemical or biological leachates may also cause severe clogging.

Different rates of flow into the two sides of the fin drain may be specified, for example, if the water flows from the verges are expected to be very different to those from the pavement structure. A value of 10 litres/m<sup>2</sup>/sec is suggested for use against the unbound mixture for sub-base and capping specified in Series 600 and 800. Very much smaller values are adequate for soils and backfills other than coarse gravels, and possibly dispersive silts or contaminated sites. It should be appreciated that, because of such long-term effects, these flow rates should not be used to determine the in-plane design requirements of the fin drain.

4. Sub-Clause 5 of Clause 514 requires specification of the in-plane flow capacity of the fin drain. This design capacity should allow for infiltration through the pavement and verges and any other source of ground water ingress. Until more accurate means of establishing infiltration rates through the pavement are available a value not less than the mean intensity of a one year 2 hour rainfall should be assumed. The fin drain Type 5 of Drawing F18 in the HCD acts both as a filter drain and a carrier pipe. Thus in-plane flow must be specified for flow both along the drain parallel to the road edge and near-vertically down the drain. For all other drain types, only near-vertical downward flow need be specified.

Fin drain Type 10 in Drawing F21 should either have an impermeable side or be covered by an impermeable membrane unless no significant blocking of the core will occur during the slip-forming of the channel.

Fin drains are normally laid at constant depth below the carriageway and their gradient will therefore follow that of the road. Drainage capacities should be designed for these gradients and outfall lengths determined accordingly. For drain Type 5 the flow rates that are stated in Appendix 5/4 should be the capacity required linearly extrapolated to the standard gradients in Table 5/8.

Where fin drains utilise a pipe, capacities may be obtained from hydraulic tables and the required diameter specified.

5. Sub-Clause 9 of Clause 514 specifies the use of as-dug material for trench backfill. If this material when compacted is sufficiently less permeable to affect the efficiency of the drain, or contains stones larger than about 100 mm which could damage the drain, an alternative material compatible with the geotextile should be used.
6. Proper functioning of the fin drain and its ancillary components depends critically on adequate installation and joining procedures.

Fin drains can be problematical during construction phase for the following reasons.

- i) They do not provide immediate drainage for the unpaved sub base.
- ii) They are not designed for surface water flows.
- iii) Fine particles transported by surface water or vehicles may clog the filter or silt the drain.
- iv) They may be damaged by the passage of construction traffic.

Appropriate protection measures must be taken, e.g. polythene sheeting, temporary drainage channels, or warning fence. Alternatively, the drains may be installed towards the end of the construction phase.

7. All fin drains and their constituents must be the subject of a British Board of Agrément Roads and Bridges Certificate which certifies the values achieved for the specified properties when tested in accordance with Clause 514. Fin drains are available in a variety of configurations with different types of core structure. In addition, several tests described in Clause 514 are modified British Standard tests or have been developed especially for the Specification and as yet there is little experience of their use.

These two factors mean that some variation or interpretation of the test method may sometimes be necessary.

The British Board of Agrément will agree details of any appropriate variations in the specified test methods following consultation with the manufacturer. It is intended that whenever the Contractor proposes the use of any fin drain or constituent material he must supply copies of the appropriate British Board of Agrément Roads and Bridges Certificate to confirm that the material complies with the Contract requirements. (Further guidance may be sought from the Overseeing Organisation).

## HMEP CL 515 SR - NARROW FILTER DRAINS

### General

1. Narrow filter drains shall comply with this Clause and the special requirements described in Appendix 5/4.

The term narrow filter drain refers to drain Types 8 or 9 indicated in the HCD Drawing Number F18. They consist of a porous or perforated pipe laid in a narrow trench surrounded by granular material where the granular material and/or the pipe is enclosed by a layer of geotextile filter. Narrow filter drains and fin drains perform the same function.

### Materials

2. The geotextile materials used in the drain shall be stored so that they are protected from the deleterious effects of short term exposure to ultraviolet light, and shall be resistant to degradation by acids, alkalis, common chemicals, bacteria, fungi and moulds occurring in soils and highway construction materials. After exposure to ultraviolet light the Overseeing Organisation may require evidence that the materials still comply with the requirements of this Clause. They shall be protected from damage and ultraviolet light and be labelled to identify the grade and manufacturer or supplier.
3. The geotextile used in narrow filter drains shall comply with all requirements of sub-Clause 514.4 for geotextiles used in fin drains.

For drain Type 8 the geotextile surround to the pipe shall consist of a prefabricated continuous close fitting sock.

Alternatively the pipe shall be firmly wrapped in a single layer of geotextile with an overlap of between 50 and 75 mm and secured around the pipe in a manner so as to prevent the ingress of soil particles or other extraneous material and without affecting the permeability of the wrapped material.

Splices between lengths of sock or layer shall have overlaps within these dimensions and be securely tied.

For drain Type 9 the geotextile surround to the granular material shall have a minimum overlap of 250 mm including 100 mm down-tuck. Splicing of lengths of geotextile shall consist of minimum 600 mm overlap secured with pins or mechanical ties. Where an outlet pipe passes through the geotextile a separate piece of geotextile shall be wrapped round the outlet pipe, flared against the geotextile in the filter drain and secured.

Where drain lengths are terminated at chambers, the geotextile shall be secured against the chamber walls by suitable means so as to prevent the ingress of soil particles or other extraneous material into the drain.

4. Pipes and fittings shall comply with sub-Clauses 514.7 and 514.8. Where coilable pipes to BS 4962 : 1989 are used they shall be capable of being straightened so as to lie flat without restraint in the trench bottom before backfilling.
5. The granular material used for trench infill shall comply with the requirements for non-plasticity, LA category and sulphate content of sub-Clause 505.3 and have a grading within the limits of Table 5/8. The material when tested in accordance with sub-Clause 509.8 shall meet the permeability requirements described in Appendix 5/4.

HCD Drain Type	8	9
Maximum Particle Size mm	40	40
D5 Size mm	>0.125	>0.125
D15 Size mm	As stated in Appendix 5/4	-
D85 Size mm	-	> Hole Diameter or 1.2 Times Width of Slot in Pipe
Uniformity Coefficient	5 to 12	5 to 12 or if Cu <5
(Cu) D60/D10		D5 > 1 mm
D <sub>n</sub> = Sieve size passing n% by weight of material		

### Dimensions

6. Unless otherwise described in Appendix 5/4 the dimensions of the narrow filter drain shall be as shown on HCD Drawing No. F18. The pipe diameter shall be as stated in Appendix 5/4. The drain slope angle (x), as shown on Drawing F20, shall be not greater than 15% from the vertical unless otherwise stated in Appendix 5/4.

### Installation and Handling

7. Narrow filter drains shall be installed as shown on HCD Drawing Number F20. Before during and after installation the geotextile shall be protected from contamination, damage and exposure to ultraviolet radiation in accordance with sub-Clause 514.11.

The excavated trench bottom shall be free of irregularities and to the required levels given in Appendix 5/4. Rock and other hard protuberances shall be removed and any excess cut in the trench bottom filled and compacted back to the required grade with suitable excavated or imported material. Drain Type 9 shall have trench walls sufficiently clean to enable the geotextile to come into close contact with the wall when the granular material is placed inside it. The deposition and compaction of infill shall be in accordance with sub-Clause 505.4 for filter drains.

Narrow filter drains installed as part of the Permanent Works shall not be used for the disposal of surface water run-off during construction. Narrow filter drains exposed to surface water ingress shall be temporarily protected.

Marker tapes shall conform and be installed in accordance with sub-Clause 514.11.

8. The Contractor shall obtain and make available the information required in sub-Clause 514.12 in respect of the geotextile and pipe.

#### **Certification**

9. The geotextile shall have a current British Board of Agrément Roads and Bridges Certificate certifying the appropriate physical properties when tested in accordance with this Clause.

## HMEP NG 515 NARROW FILTER DRAINS

1. Narrow filter drains are intended for use as edge of pavement sub-surface drains and are suitable alternatives to fin drains for this purpose. Both types have the same requirements of performance and the guidance given in NG 514 is equally applicable to determining the soil retention and permeability criteria of the geotextile used in narrow filter drains and to the discharge capacity of the drain. In normal circumstances, the Contractor should be permitted the choice of any of the types shown in the HCD. If however, for engineering reasons, exclusion of a particular type is required, this should be stated in Appendix 5/4.
2. In drain Type 8 the filtration function is achieved by a granular filter material and geotextile sock and in Type 9 by means of a geotextile wrapping to the drain. Both filters should be designed to be compatible with the adjacent soil or construction layer. For the Type 8 drain granular material the value of D15 to be specified (Table 5/8) should be based on the criteria D15F less than or equal to 5 x D85S (TRRL Report LR346) where D85S is the sieve size passing 85% by weight of the adjacent soil. The geotextile sock around the pipe is a second stage filter where it is required to retain the particles of the first stage granular material. However, the pipe when laid in the narrow trench may have insufficient granular surround for fully effective first stage filtration to be achieved. Pore sizes for the sock material should therefore be designed to also retain the finer soil particles outside the trench.
3. The specification for granular material in Table 5/8 is intended to permit the widest range of available material to be used. These limits have been set to reduce the risk of damage to the geotextile, to avoid gap grading of the filter material and to ensure an adequate degree of permeability. For the material as specified a minimum value of permeability of about  $1 \times 10^{-4}$  m/second which is similar to that obtained by a clean coarse sand may be assumed. A higher permeability will rarely be necessary but if required it may be specified in Appendix 5/4.
4. Narrow filter drains require protection during the construction phase similar to that provided for fin drains (see NG 514.6).
5. The geotextiles used in narrow filter drains require British Board of Agrément Road and Bridges certification (see NG 514.7).

## HMEP CL 516 SR - COMBINED DRAINAGE AND KERB SYSTEMS

### General

1. Combined drainage and kerb systems listed in Appendix 11/1 shall be treated as other features to be designed by the Contractor. Combined drainage and kerb systems shall conform to BS EN 1433 and to the special requirements in Appendix 5/5.
2. Combined drainage and kerb systems shall be suitable for their intended use and place of installation in the Works and as stated in Appendix 5/1. The Contractor shall provide evidence of such suitability for the purpose to the Overseeing Organisation in accordance with Appendix 1/5.
3. Design flows given in Appendix 5/5 shall be accommodated without surcharge within the main combined drainage and kerb section and beneath the underside of any inlet slot sections.
4. Where applicable, the width and depth of combined drainage and kerb system units shall not exceed the dimensions given in Appendix 5/5.
5. When used adjacent to porous asphalt surfacing materials, units shall incorporate side entry inlets to permit drainage of water held within the porous asphalt. Inlets shall comply with the requirements of Appendix 5/5 and shall have the capacity to drain porous asphalt.

### Classification

6. Combined drainage and kerb systems, excluding in-situ system, shall be classified as follows according to their intended use and shall be as stated in Appendix 5/5:
  - (i) C 250;
  - (ii) D 400; and
  - (iii) where, exceptionally, combined kerb and drainage units have to be located in areas subjected to large numbers of high speed heavy goods vehicles, Class E600 combined kerb and drainage units shall be considered.

### Water Tightness

7. Joints between units comprising the system and between the channel and units, shall be designed to avoid leakage of surface water. Joints between bridge deck waterproofing and component parts passing through the waterproofing shall be watertight. Sealants shall be compatible with the waterproofing system.

### Installation and Handling

8. Combined drainage and kerb systems shall be laid and jointed in accordance with the manufacturer's written instructions.
9. Adjacent carriageway, footway, verge or central reserve to bedding, backing, surrounding or jointing of combined drainage and kerb units shall be in accordance with the manufacturer's written instructions.
10. Junctions, connecting pipes and other fittings comprising the combined drainage and kerb system shall comply with sub-Clause 501.3 and shall be as described in Appendix 5/5. The combined drainage and kerb system shall incorporate measures to enable rodding of the outfall pipe work and adequate access for jetting by water jetting equipment into the system.

### Cleaning

11. Combined drainage and kerb systems shall be cleaned out by appropriate means and shall be left clean and free from all obstruction. The completed combined drainage and kerb systems shall be surveyed by Closed Circuit Television (CCTV) in accordance with the relevant requirements of Series 9000 (Manual of Contract Documents for Highway Works 5.9, Parts 1 to 5).

### HMEP NG 516 COMBINED DRAINAGE AND KERB SYSTEMS

1. The drawings should show the location and gradient(s) of the combined drainage and kerb system, the position of access, silt trap, outfall and end units together with the position and invert level of the surface water outfall connection. The position of any movement joints required in the system, e.g. at joints in bridge decks or concrete carriageways, should be shown. Details of any ducts, cabling, etc, required to pass under the kerb should be shown. The extent of the work to be designed by the Contractor should be clearly defined.
2. Combined drainage and kerb systems should be scheduled in Appendix 11/1 and cross-reference made to the design requirements given in Appendix 5/5.
3. Advice on the location of Class C and Class D systems is given in sub-Clause NG 517.1.

### HMEP CL 517 SR - LINEAR DRAINAGE CHANNEL SYSTEMS GENERAL

1. The linear drainage channel systems listed in Appendix 11/1 shall be treated as other features to be designed by the Contractor. The in-situ linear drainage channel systems shall conform, where applicable, to sub-Clauses 517.2 to 517.17 and the

requirements in Appendix 5/6 and Appendix 11/1 as appropriate. The prefabricated linear drainage channel systems, where applicable, shall conform to BS EN 1433 and with the other requirements in Appendix 1/5.

2. Linear drainage channel systems shall be suitable for their intended use and place of installation in the Works. The Contractor shall provide evidence of such suitability for the purpose to the Overseeing Organisation in accordance with Appendix 1/5.
3. Design flows given in Appendix 5/6 shall be accommodated without surcharge within the main channel section and beneath the underside of any inlet slot sections.
4. Where applicable, the width and depth of linear drainage channel system units shall **not exceed the dimensions given in Appendix 5/6.**
5. Dimensions of inlet slots shall comply with the following criteria:
  - (i) for prefabricated linear drainage channel systems they shall conform to BS EN 1433;
  - (ii) for in-situ linear drainage channel systems they shall conform to BS EN 1433.
6. When used adjacent to porous asphalt surfacing materials, units shall also incorporate side entry inlets to permit drainage of water held within the porous asphalt. Inlets shall comply with the requirements of Appendix 5/6 and shall have the capacity to drain porous asphalt.

### **Weathering Resistance**

7. Marking relating to the grade of weathering resistance for drainage channels made of concrete shall be as stated in Appendix 5/6.

### **Classification**

8. Linear drainage channel systems shall be classified as follows according to their intended use and shall be as stated in Appendix 5/6:
  - (i) C 250;
  - (ii) D 400; and
  - (iii) where, exceptionally, linear drainage channel systems have to be located in areas subjected to large numbers of high speed heavy goods vehicles, Class E600 combined kerb and drainage units shall be considered.

### **Water Tightness**

9. Joints between units comprising the system and between adjacent construction and the system shall be designed to avoid leakage of surface water. Where applicable, joints between bridge deck waterproofing and component parts passing through the waterproofing shall be watertight. Sealants shall also be compatible with the waterproofing system.

10. Junctions, connecting pipes and other fittings comprising the linear drainage channel system shall comply with sub-Clause 501.3 and shall be as described in Appendix 5/6. The linear drainage channel system shall incorporate measures to enable rodding of the outfall pipe work and adequate access for jetting by water jetting equipment into the system.

### **Cleaning**

11. The linear drainage channel systems shall be cleaned out by appropriate means and shall be left clean and free from all obstruction on completion of the Works. The completed linear drainage channel systems shall be surveyed by Closed Circuit Television (CCTV) in accordance with the relevant requirements of Series 9000 (Manual of Contract Documents for Highway Works 5.9, Parts 1 to 5). Further guidance is provided in sub-Clauses NG 509.4 and NG 509.5.

### **Manufactured Systems**

12. Manufactured systems shall conform to BS EN 1433.

### **In-situ Systems**

13. In-situ systems shall comply with the requirements of sub-Clauses 1103.1, 1103.3 and 1103.4. They shall comply with the requirements of sub-Clause 1103.2 except that the concrete shall be considered as plain concrete within the terms of this sub-Clause, irrespective of the inclusion of reinforcement.
14. In-situ systems shall be slip formed except for sections at gullies which shall be hand formed. Full depth joints shall be constructed at the interface at each side of gullies with a 25 mm thick filler board complying with Clause 1015 and sealed in accordance with Clauses 1016 and 1017.
15. The central void may be formed by an inflated tube which is then removed, or by an insitu suitable pipe or similar former fit for the purpose. At gully positions the inner former shall be pre-sleeved with a suitable pipe or similar former fit for the purpose which shall be of sufficient length to overlap the two joints on either side of the gully.
16. The central void shall be checked in accordance with sub-Clause 509.4. Verification of slot widths shall be determined by suitable templates.
17. Reinforcement shall comply with Series 1700. Cover to reinforcement shall be not less than 75 mm.
18. Trial lengths and testing of in-situ channels shall be undertaken in accordance with clauses 6 and 8.6 of BS 5931 and the relevant paragraphs of clause 9 of BS EN 1433 respectively.

## HMEP NG 517 LINEAR DRAINAGE CHANNEL SYSTEMS

1. The linear drainage channels specified in Clause 517 may be used in public highways. Class D channels are designed to withstand loadings of all types of road vehicle that are permitted on public highways. Class C channels should only be installed in locations which are protected from direct traffic loading, e.g. in areas behind safety barriers. The range of slot dimensions permissible within Clause 517 is not compatible with safe usage by cyclists and pedestrians, and units with slot dimensions described in Clause 517 should not be used in areas subject to such traffic.
2. The Drawings should show the location of the linear drainage systems and the positions of the surface water outfall chambers into which the systems are to outfall. The position of any movement joints required in the system, e.g. at joints in bridge decks or concrete carriageways, should be shown. Details of any ducts, cabling, etc., required to pass under the systems should be shown. The extent of the work to be designed by the Contractor should be clearly defined.
3. Linear drainage channel systems should be scheduled in Appendix 11/1 and cross reference made to the design requirements given in Appendix 5/6.
4. Variations to stated dimensions may be considered providing that the product will meet the requirements of this specification.
5. A system comprising units which may be otherwise too small to accommodate design flows without surcharge may be acceptable in conjunction with the provision of additional intermediate or upstream chambers subject to the following requirements:
  - a) Intermediate chambers should be compatible with the standards of the chambers shown on the Drawings and any longitudinal drains connecting such chambers should also be connected into the intermediate chambers.
  - b) Not more than one intermediate chamber should be permitted between the upstream and downstream chambers of any drain shown on the Drawings.
  - c) Not more than one additional chamber should be permitted upstream of each upstream chamber shown on the Drawings.

## HMEP CL 518 SR - THERMOPLASTICS STRUCTURED WALL PIPES AND FITTINGS

### General

1. Thermoplastics structured wall pipe shall comply with this Clause and the special requirements described in Appendix 5/1.

The term structured wall pipe shall mean all types of smooth bore pipe except solid wall homogeneous pipe. Typical forms of construction classified as structured wall pipes include: single wall externally structured smooth bore, twin wall, foamed core and spirally wound.

The term fitting shall mean a product used in conjunction with the pipe to form the system but excluding gullies manhole chambers, inspection chambers and access chambers.

### Materials

2. The materials from which the pipe and fittings are made, shall be treated so that they are protected from the deleterious effects of short term exposure to ultraviolet light, and shall be resistant to degradation by acids, alkalis, common chemicals, bacteria, fungi and moulds occurring in soil, highway construction materials and highway drainage systems. In addition, the materials from which the pipe and fittings are made, shall not incorporate any additives in quantities sufficient to cause microbiological degradation or to impair the conformity to the chemical, physical and mechanical properties or impact resistance requirements given in sub-Clause 5 of this Clause. The specification of the raw material shall be agreed between the certification body, as defined in sub-Clause 15 of this Clause, and the manufacturer and may incorporate re-processable and/or recyclable material. The agreed specification shall incorporate tolerances for each of the relevant characteristics defined in the appropriate clause of prEN 13476. The Contractor shall submit to the Overseeing Organisation, prior to commencement of the Works, completed information sheets in accordance with Appendix 5/7.

### Dimensions

3. Systems for carrier drainage shall be between 150 mm and 900 mm nominal internal diameter. Pipes for narrow filter drains shall be 110 mm or 150 mm nominal internal diameter. Pipes for service ducts shall have nominal internal diameters of between 50 mm and 150 mm. Pipes for sub-soil drainage shall incorporate slots or holes with a minimum cross sectional area of 1000 mm<sup>2</sup> per metre run of pipe.

The bore of the pipe and fittings shall be in accordance with the standard tolerances for nominal bores given in BS EN 476.

## Appearance

4. The system shall have a smooth bore and be free from any burs, flash or other inconsistencies that could have a detrimental effect on the performance of the system. Pipes and fittings for drainage shall be externally coloured either terracotta or black. The colour of ducting pipes shall be in accordance with National Joint Utilities Group publication “Guidelines on the Positioning and Colour Coding of Utilities’ Apparatus”. Any variation in the colour shall be described in Appendix 5/2

## Structured Wall Pipe

5. The structured wall pipe shall have the properties defined in Table 5/9.

Property	Relevant Standard	Requirement
General	BS EN ISO 2897-1, BS EN ISO 2897-2 and BS ISO 11922-1	Dimensions to be specified
Ring stiffness	BS EN ISO 9969	6 kN/m <sup>2</sup> minimum. Lower stiffness values are permitted if design calculations to BS EN 1295-1 (UK national annex), based on site specific installation conditions, indicate satisfactory performance.
Creep Ratio	BS EN ISO 9967	PVC-U- maximum 2.5 PP and PE- maximum 4.0
High volume low pressure jetting	WRc Jetting Test Method	Minimum acceptable failure pressure 137 bar.
Longitudinal bending	sub-Clause 518.11	Pipes with nominal diameters $\leq$ 350 mm to have a difference in dimensions when measured in the vertical axis of less than 5% of the pipe length and no local permanent deformation occurs during the test.
Impact resistance at 0°C	BS EN 1411 with d25 striker of 1 kg	Preliminary test – test 10 pieces as described in BS EN 1411, dropping the striker from a height of 1m. If any test pieces fail, subject the pipe to the full test given in clause 7.3 of BS EN 1411 starting the striker from a drop height of 400 mm. The mean minus 1.64 times the standard deviation must exceed 1m.

Impact resistance at 23°C	BS EN 1411 with striker as above	Value to be derived from the same batch of pipe as used in the impact resistance test at 0°C. The H50 (mean) value - 10% to be used as the minimum value for quality control testing. Alternatively the 0°C test can be used as a QC test if the manufacturer chooses.
Rodding resistance	sub-Clause 518.12	Pipes with nominal diameters $\leq 350$ mm to have an average failure energy $>3$ joules
Static friction coefficient (ducts)	TS 12-24	Pass
Creep at elevated temperature (ducts)	BS EN ISO 9967	Test to be carried out at 45°C, creep ratio to be less than 2 times the values to BS EN ISO 9967.
Resistance to point loads (ducts)	sub-Clause 518.13	No perforation at 10% rod travel
Tensile strength of a seam	BS EN 1979	prEN 13476

### Fittings

6. The fittings for use with structured wall pipe shall have the properties defined in Table 5/10.

Property	Relevant Standard	Requirement
General	BS EN ISO 2897-1, BS EN ISO 2897-2 and BS EN ISO 11922-1	Dimensions to be specified
Ring stiffness (excluding couplers)	ISO 13967	6 kN/m <sup>2</sup> minimum

Rodding resistance	sub-Clause 518.12	Fittings with nominal diameters $\leq 350$ mm to have an average failure energy $>3$ joules
Strength and flexibility of fabricated fittings	BS EN 12256	BS EN 12256
Impact resistance (drop test)	Drop Test to BS EN 12061: 1999	Fall height 1000 mm at a temperature of 0°C. Product less than ND 300 shall show 'no damage'. Others may fail but must be identified as 'handle with care'
Watertightness of fabricated fittings	BS EN 1053	0.5 bar for 1 minute

### Pipe and Fittings

7. The pipe and fittings shall have the properties defined in Table 5/11.

Property	Relevant Standard	Requirement
Leak tightness of joints - diameter distortion (watertight joints)	BS EN 1277 Method 4 Condition B Temperature (23 ± 2)°C	Use default values from BS EN 1277
Leak tightness of joints - angular deflection (watertight joints)	BS EN 1277 Method 4 Condition C Temperature (23 ± 2)°C	Use default values from BS EN 1277
Leakage rate from partially-watertight joints	Sub-Clause 509.7	Less than 20 times the square of the ID of the pipe in metres shall flow through the joint in litres per minute
Resistance to wheel loads	BS EN 1437 adapted to suit HA loading conditions	Less than 5% deformation when loaded to 100 kN (for unequal branches only)

### Bedding, Backfill and Surround Material

8. All systems shall be installed in accordance with the pipe and bedding combinations given in Advice Note HA 40 (DMRB 4.2.5). Other combinations shall be supported by calculations in accordance with BS EN 1295-1 UK National Annex. Bedding, backfill and surround materials are classified in Clause 503 and Clause 505.

### Installation and Handling

9. The bedding, surround and backfill shall be installed so as to cause no damage to the pipes and fittings. Installation of the pipe and fittings, particularly, procedures for preparation and execution of jointing operations, shall be in accordance with the manufacturer's instructions.

### Identification

10. The Contractor shall maintain records with the following information for each separate consignment of structured wall pipe or fittings delivered to Site:
- (i) system name, ring stiffness grade/number and size;
  - (ii) name and address of the system manufacturer;
  - (iii) consignment number and delivery date; and
  - (iv) a copy of the site delivery note.

### Test Method for Longitudinal Bending

11. (i) The test specimen shall be a six metre length of pipe or the maximum length available from the manufacturer (if less than six metres).
- (ii) The apparatus shall include:
- (a) two level support blocks at least 250 mm wide and of sufficient height to allow the pipe to sag over its length without touching the ground;
  - (b) a means of measuring the vertical distance between the pipe at the centre of the span and a fixed point of reference to an accuracy of  $\pm 0.5$  mm.
- (iii) The test procedure shall be as follows:
- (a) condition the specimen for at least 1 hour at  $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ;
  - (b) set the supports at a distance apart equal to the length of pipe minus 500 mm;
  - (c) place the pipe symmetrically on the supports;
  - (d) measure the distance between the top of the supports and the fixed point of reference, in the vertical axis through the centre line of the pipe;

- (e) after a period of two minutes measure the distance between the underside of the pipe at mid span and the fixed point of reference;
- (f) record the difference in readings as a percentage of pipe length.

#### Test Method for Rodding Resistance (Internal Puncture)

12. (i) The test specimens shall be:
  - (a) twenty specimens cut from the structured wall pipe, each specimen to be 242 mm to 246 mm in length and a quarter section of the circumference or;
  - (b) twenty specimens cut from a number of identical fittings.
- (ii) The apparatus shall include:
  - (a) a standard drop weight pipe testing apparatus capable of dropping a tup from a height of 1 m;
  - (b) a 300g tup which can be varied in 30g multiples with a striker consisting a steel rod 18 mm in diameter with a 9 mm hemispherical end;
  - (c) a 250 mm x 250 mm box containing dry Leighton Buzzard sand (Garside quarry) such that there is at least 100 mm of sand beneath the test specimen when bedded down.
- (iii) Procedure shall be as follows:
  - (a) mark the intended point on the inside of the pipe on the intersection of the centre lines. With profiled pipes the point of impact shall be at the point nearest the intersection that mid way between the ribs or in the middle of a hollow corrugation;
  - (b) alternatively mark the intended point of impact on the section of fitting;
  - (c) condition the test specimens in air at a temperature of  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$  for a period of at least one hour before the test;
  - (d) locate the box under the drop tube of the impact apparatus;
  - (e) embed the specimen into the sand using a vibrator with the inner surface exposed and facing upwards;
  - (f) locate the specimen such that the marked point of impact is under the centre line of the tup;
  - (g) drop the tup from a height of 1 m on to the inner surface of the specimen within 10 seconds of removing the specimen from the conditioning environment;

- (h) examine the specimen for damage. Damage is defined as a puncture or crack of the inner layer. Ductile bending or “whitening” is not considered to be damage;
  - (i) if the specimen exhibits no damage the next test shall be conducted with a tup of 30 g greater mass. If the specimen does exhibit damage the next test shall be conducted using a tup of 30 g smaller mass;
  - (j) after having completed the 20 strikes calculate the average of the energies where a pass (no damage) was recorded and the average of the energies where a failure (damage) was recorded, then calculate the average of the two averages.
- (iv) The test report shall include:
- (a) identification of the samples;
  - (b) the overall average;
  - (c) whether or not the specimens were damaged.

#### Test Method for Resistance to Sharp Objects

13. (i) Test specimens shall be three samples of duct each 300 mm long.
- (ii) The apparatus shall include:
- (a) a compression testing machine;
  - (b) a 4.7 mm diameter steel rod with an hemispherical end;
  - (c) and a 120° steel vee block at least 300 mm long.
- (iii) The test method shall be as follows:
- (a) condition the test specimens for at least 1 hour at  $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ;
  - (b) insert the steel rod in the jaws of the moveable platen of the compression testing machine so that the hemispherical end protrudes at least 15% of the nominal pipe diameter;
  - (c) position the specimen in the vee block and place directly below the steel rod, for twin-walled pipe the specimen shall be positioned firstly so that the rod strikes on the corrugation or rib, and secondly in the valley (where possible);
  - (d) set the machine to lower at a rate of 5 mm/min;
  - (e) allow the rod to travel into the pipe a distance equal to 10% of the nominal internal diameter of the pipe ( $T_{10}$  mm) or until the pipe wall is perforated. When the outer skin of a twin wall pipe is perforated before

10% is attained, the rod travel up to the point of failure shall be recorded ( $T_f$  mm) and the rod allowed to travel to the inner wall. The rod travel shall be continued to a total of 10% (ie  $T_{10} - T_f$ ) or until complete penetration occurs.

- (iv) For each test specimen: pipe size, reference, maximum load and rod travel shall be recorded.

14. Notwithstanding the requirements of sub-Clauses 11, 12 and 13 of this Clause, variations in the test methods specified therein shall be made where deemed necessary by the British Board of Agrément (or equivalent) following consultation with the manufacturer and in agreement with the Overseeing Organisation. All such variations shall be recorded in the report.

### **Certification**

15. Pipes and fittings shall have a current British Board of Agrément Roads and Bridges Certificate (or equivalent) certifying the appropriate physical properties when tested in accordance with this Clause.

## HMEP NG 518 THERMOPLASTICS STRUCTURED WALL PIPES AND FITTINGS

### General

1. Where thermoplastics structured wall pipes and fittings are included in the schedules of permitted alternatives in Appendix 5/1, the material properties required of the different pipe materials should be specified by the manufacturer in the format given in Appendix 5/7. The third party certification body verifies these properties against the declared specification. Fulfilment of the performance requirements in conjunction with maintaining the material specification should provide the required durability for the product (i.e. a minimum life of 45 years).

### Materials

2. Most thermoplastics are stable against common chemicals found in ground water and in surface water runoff. Further details on the suitability of a particular compound can be found in CP 312 : 1976.

The pipes and fittings should be protected against prolonged exposure to sunlight and it may be necessary for the Contractor to cover the pipes prior to installation.

### Dimensions

3. Dimensions should be measured in accordance with prEN ISO 3126 and should fulfil the requirements of sub-Clause 518.3 and the declared specification (see Appendix 5/7).

### Appearance

4. The bore of the pipe fittings should be smooth to allow the correct choice of Manning's coefficient for hydraulic design of the system.

### Structured Wall Pipe

5. Table 5/9 gives the requirements for structured wall pipes. Where reference is made to British, European or International Standards, these standards should be consulted to discern the relevant test conditions for the product.

Where no standard test method is available, the test method is described in sub-Clauses 518.11 to 518.13. Additional information is given in Table NG 5/1.

TABLE NG 5/1 Additional Information for Structured Wall Pipe	
Property	Additional Information
General	Quality control and identification
Ring stiffness	Manufacturer's minimum specification is required for calculation to BS EN 1295
Creep Ratio	Manufacturer's maximum specification is required for calculation to BS EN 1295.  Note: the long-term ring stiffness used for design purposes is the two year stiffness and is calculated by dividing the ring stiffness by the creep ratio
High volume low pressure jetting	A pass is deemed to also establish satisfactory performance at high volume and low pressure
Longitudinal bending	To reduce the possibility of problems caused by handling on site
Impact resistance at 0°C	The d50 striker is non-standard
Impact resistance at 23°C	For quality control only
Rodding resistance	To simulate effects of drain rodding
Creep at elevated temperature (ducts)	To simulate the effect of exposure to high temperatures that may occur in power cable ducts
Resistance to point loads (ducts)	Simulate sharp aggregate penetration
<p>Note</p> <p>1: When carrying out calculations to BS EN 1295 the minimum value for stiffness and the maximum value of creep ratio should be used in order to establish the long term stiffness. For example, a pipe might have a declared minimum stiffness of 4.5 and a maximum declared creep ratio of 3.8. The long-term stiffness would be <math>4.5/3.8 = 1.18 \text{ kN/m}^2</math>. Site-specific calculations, in accordance with BS EN 1295, can be used to establish that the long term deformation will be less than 5% and the safety factor against buckling greater than two.</p>	
<b>Fittings</b>	
6. As stated in sub-Clause 5 of this Clause the standards should be consulted to	

discern the relevant test conditions for the product against the requirements given in Table 5/10.

### Installation and Handling

7. Care should be taken to prevent changes in line or level when placing the surround material over the pipe crown, as there is the possibility of flotation (see also sub-Clause 503.6).

Compaction levels of all sidefill and backfill material must be closely monitored as these have a direct impact on the ground settlement and pipe deflection characteristics. Special precautions may be necessary where the system is subject to high construction loading such as spreader plates.

8. Installation and compaction of the pipe and surround are key to the performance and durability of the system. The pipe must be installed to line and level and any pipe that is out of shape should not be installed. The change in shape could be caused by, longitudinal bending, mechanical damage or deformation under lifting and installation. Larger diameter pipes and fittings must be handled with care as they are more likely to suffer impact damage especially at lower temperatures. Reference should be made to the HSE Manual Handling Operations Regulations 1992 guide 'Guidance on Regulations L/23 1998', where appropriate, and care taken whilst using mechanical plant especially near to trench walls. The manufacturer must supply the weight per metre of the pipe and from this information the Contractor is able to assess the lifting needs for installation of the pipe.

### Test Method for Longitudinal Bending

9. The test is intended to eliminate very flexible pipe (e.g. coilable pipe) and pipe which is so weak that it might deform whilst being handled on site.
10. The two level support blocks at least 250 mm wide and of sufficient height to allow the pipe to sag over its length without touching the ground could consist of standard building blocks stood on their ends.

### Test Method for Rodding Resistance (Internal Puncture)

11. The test is intended to simulate damage which might be caused by the ferrule of a drain cleaning rod being impacted against the inside of the pipe or fitting during cleaning operations and is intended to ensure the structural integrity of the inner layer. A segment of pipe or a section from a fitting is subjected to impact on its internal surface whilst fully supported by its external surface.

### Test Method for Resistance to Sharp Objects

12. The test is intended to simulate the effect of penetration due to sharp aggregate and is intended to exclude ducts with particularly thin wall section.

## HMEP CL 520 (SR) - THE CLEANING OF EXISTING DRAINAGE SYSTEMS

1. Where stated in Appendix 5/1, the Contractor shall clean existing drainage systems in accordance with this Clause.
2. The Contractor shall take measures when clearing blocked drains to ensure that adjacent water courses or groundwater via soakaways, will not be contaminated. Contamination includes mud or soil being washed or flushed into streams as well as other more obvious contaminants including diesel fuel, oil and chemicals.
3. Unless detailed in Appendix 5/1 initial attempts to clear blocked drains shall be undertaken by hand rodding and any debris and silt removed by the operation shall be removed off site. The Contractor shall report any localised blockages that cannot be cleared by rodding to the Overseeing Organisation
4. Where jetting is required in Appendix 5/1 the procedures stated in Clause 521 shall be followed.

### Cleaning of Gullies, Catchpits, Soakaways and Oil Separators

5. At each chamber all mud and vegetation in the vicinity of the chamber likely to impede the flow of water shall be removed. After lifting the cover or grating the chamber shall be cleansed of all water, detritus, debris and silt, refilled with clean water to the outlet level, and all covers and gratings replaced and evenly bedded.
6. Cleaning of chambers shall be by mechanical means. The vehicle used to clean existing chambers shall be equipped with a 125 mm dia. gulley output of 5.95 cum/min and minimum 5455 litres capacity.

Sediment, detritus and liquor from the chamber shall not be permitted to discharge into the outlet.

This may be achieved either by plugging the outlet during cleaning, or by simultaneous jetting and abstraction of liquor from the chamber using a tanker fitted with low pressure high volume water jets around the boom.

7. Gullies and chambers not cleaned for whatever reason, blocked connections and broken or cracked covers, gratings or frames shall be marked to aid subsequent identification.
8. Oil separators shall be refilled with uncontaminated water following the cleaning operation.
9. The Contractor shall dispose of all surplus water, debris and arisings from the works off Site at a licensed tip.

### **Cleaning or Testing of Piped Drainage Systems and Subway Drainage Channels**

10. Routine cleaning or testing of piped drainage systems and subway drainage channels shall be carried out by rodding or low pressure high volume jetting in accordance with Clause 521.
11. The location of any obstruction that cannot be removed by flushing shall be marked on the ground using a wooden peg or other semi-permanent means and reported to the Overseeing Organisation using the Routine Maintenance Manual System (RMMS) referencing system in Part 3, Chapter 3.7.
12. All covers which have been removed for cleaning operations shall be replaced and evenly bedded.
13. The Contractor shall report any damage and defects to the drainage system or components to the Overseeing Organisation each day, or immediately if considered a safety hazard.

### **Cleaning Kerb or Channel Offlet Pipes**

14. Where necessary all vegetation and debris shall be removed from around metal kerb weirs and the cover lifted for cleaning.
15. Offlets shall be cleaned such that all silt and loose obstructions are removed from the pipe. This shall be achieved by rodding or by using lorry-mounted drain clearance equipment comprising combination pressure jetting with high air flow suction equipment. The vehicle shall also be equipped with a hydraulically powered grid lifter.
16. The Contractor shall ensure that each end of the offlet is free from vegetation or other obstructions including any material expelled from the pipe. Where the invert of the outlet is below the invert of the ditch, the bottom of the ditch shall be excavated until the invert of the pipe is exposed and the ditch invert regraded to facilitate flow from the outlet.
17. The location of any obstruction that cannot be removed shall be marked on the ground using a wooden peg or other semi-permanent means and reported to the Overseeing Organisation.
18. All covers lifted for cleaning operations shall be replaced and evenly bedded.

### **Cleaning of Bridge Drainage Systems**

19. Cleaning of bridge bearing shelves, subway sumps, grit chambers and other bridge drainage systems shall be carried out by one of the following methods:
  - (i) vacuum/air suction having the ability to remove materials from depths of up to 9.0 m with a suction facility capable of displacing 55 m<sup>3</sup>/min of air at 95% vacuum;
  - (ii) low pressure high volume jetting in accordance with Clause 521;

- (iii) sweeping.
- 20. All adjacent surfaces of the structure shall be protected to prevent staining by arisings from the cleaning operation. All arisings shall be taken off Site.
- 21. The Contractor shall report to the Overseeing Organisation any damage or defects to the bridge drainage systems.

## **HMEP CL 521 SR - LOW PRESSURE HIGH VOLUME JETTING OF DRAINAGE SYSTEMS**

1. Where stated in Appendix 5/1, the Contractor shall clean existing drainage systems in accordance with this Clause.
2. The drainage systems to be cleaned shall be as detailed in the Appendix 5/1.
3. The pipe material of the drainage systems to be cleaned shall be identified in Appendix 5/1. Where the material is unknown and cannot be verified by either visual inspection, without recourse to man-entry, or from drainage records, or damage to the pipeline is the suspected cause of a blockage, cleaning shall proceed on the basis of use of the lowest pump pressure stated in Table 5/12.
4. Where the cleaning forms part of the pre-cleansing works for the CCTV survey of drainage systems, the works shall be detailed in Appendix 90/1 (see Model Contract Documents for CCTV Survey of Highway Drainage, (Manual of Contract Documents for Highway Works 5.9.3).

### **Jetting of Piped Drainage Systems**

5. Cleaning shall take place from downstream of the blockage in an upstream direction. The pipe shall be plugged below the jetting point to prevent contaminants flowing to the watercourse. The cleaning shall take place from a chamber, although it may be necessary to make a temporary excavation into the pipeline in some circumstances.
6. Should the Contractor find that it is not possible to jet in an upstream direction, then the pipe shall be plugged below the blockage and the jetter then used to “back jet” to a suction hose.

<b>Material</b>	<b>Maximum pump pressure (bar/psi)</b>
Unknown/structurally damaged	80/1200
Brick/masonry	100/1500
Plastics - Structural Wall	127/1900
Plastics - Solid Wall	127/1900
Concrete	340/5000
Clay	340/5000

7. The Contractor shall select a jethead that is appropriate for delivering the maximum jetting pressure for the pipe material and also the minimum volume of water for the appropriate pipe diameter stated in Table 5/13.

<b>Pipe Diameter</b>	<b>Minimum jetting flows</b>
<230 mm	156 l/m
450 mm	270 l/m
900 mm	300 l/m
1600 mm	342 l/m

8. The jet head shall be of a configuration such that the number and direction of jets are adequate to be directed to the sides and soffit of the pipeline to prevent debris passing over the top of the jetting head.
9. The Contractor shall provide suitable jetting equipment that shall include the provision of the following:
- (i) operation at a maximum rate of 850 l/min at 150 bar/2250 psi;
  - (ii) liquid ring vacuum pump operating with air flows of 4000 m<sup>3</sup> per hour, with a working vacuum of not less than 90%;
  - (iii) a minimum of 20 m of 100 mm diameter suction hose for cleaning pipes up to 300 mm diameter and 150 mm diameter suction hose for cleaning pipes of diameter greater than 300 mm;

- (iv) minimum of 150 m of 25 mm or 38 mm diameter jetting hose and a capability of jetting up to 200 m;
  - (v) automatic and continuous water recycling;
  - (vi) silt, sand and rubble to be de-watered prior to discharge at licensed tip.
10. The Contractor shall ensure that no damage occurs to the manhole chamber or pipeline during insertion of the jetting equipment.
  11. The jetting head shall be propelled through or over the blockage and then the hose pulled backwards enabling the force of the jet to break up the blockage material. The minimum force necessary to penetrate the blockage shall be used but the pump pressures should not exceed those stated in Table 5/12.
  12. The hose shall be rewound at a rate of between 100 mm and 200 mm per second.
  13. There is a possibility that damage may occur to certain pipe materials should the jetting head remain stationary thus the Contractor must ensure that the jetting head **never remains stationary for more than 60 seconds.**
  14. Perforated pipes and porous concrete pipes commonly occur in piped highway drainage systems. Where their presence is discovered during the course of the works, the Overseeing Organisation shall be notified immediately and the cleaning operation suspended for that section of the works.

### Cleaning of Linear Drainage Systems

15. Where possible the Contractor shall clear blockages in linear drainage channels and combined kerb drainage units by rodding.
16. Where silt removal is necessitated, the use of pressure jetting will result in the loss of pressure through the grating, slot or drainage holes together with the escape of silt and debris, unless the apertures can be temporarily covered. The application of pressure shall be regulated such that there is only sufficient to drive the jetting head across the silt to access remote from the point of entry.
17. If necessary the jetting head shall be changed for one that can deliver the highest volume of water at low pressure. The water pressure shall be sufficient to agitate the silt.
18. The nozzle shall be drawn back to the point of entry at a rate of between 100 mm and 200 mm per second.

### Silt Removal

19. Suitable measures such as tanks or stoppers shall be positioned downstream of the drainage system to be cleaned to minimise the risk of sediment causing contamination of watercourses or soakaways.
20. Wherever practical the Contractor shall use equipment to carry debris over a greater depth than one atmosphere and with a capability to suck liquid.
21. All arisings from the cleaning process shall be disposed of in an environmentally sensitive manner in accordance with current legislation.

### Health and Safety

22. The use of high pressure water can result in serious internal injuries that may not be apparent at the skin surface.
23. The Contractor shall ensure that all hoses are free from damage and that the equipment is in full working order.
24. Where overhead electric cables are present, there is a potential danger from accidental strike by a jet of water. The Contractor shall ensure that operatives are made aware of the presence of all overhead electric cables prior to the commencement of operations.

### HMEP NG 521 LOW PRESSURE HIGH VOLUME JETTING OF DRAINAGE SYSTEMS GENERAL

1. The location of the drainage system to be cleaned should be stated in Appendix 5/1. The details should include the locations, type of pipe material, where known, pipe diameter or state the type of system if not piped.
2. Where pitch fibre, porous concrete or perforated pipes are known to be present, these should be identified in Appendix 5/1 and the Contractor made aware of their presence.
3. If the Works are required to be detailed in accordance with Appendix 90/1 of Series 9000 (Manual of Contract Documents for Highway Works 5.9.3), the Compiler's attention is drawn to the need to ensure also that the relevant sections of the Method of Measurement for the Series 9000 are included (and amended if necessary) within the scheme specific documents.

### Jetting of Piped Drainage Systems

4. An alternative method of cleaning should be used for porous concrete or perforated pipes. There is a risk to the structural integrity of the porous pipes and a risk that exfiltration will enter the unbound pavement layers and wash out fine material in both instances. This may cause voids to form and result in premature pavement

failure. Pitch fibre pipes should be treated as “unknown/ structurally damaged” in accordance with Table 5/12.

### Jetting of Linear Drainage Systems

5. The type of linear drainage system should be detailed in Appendix 5/1.
6. The use of a high pressure lance may be used externally to clear gratings or slots of linear drainage systems.

### Silt Removal

7. The pipeline should be deemed to be clean when the silt content of the cross-sectional area of the pipe is between 0 and 10% for pipes  $\leq 600$  mm and between 0 and 5% for pipes  $> 600$  mm diameter.

### Health and Safety

8. The Contractor should undertake the works in accordance with the Health and Safety at Work etc Act (1974), the Construction (Health, Safety and Welfare) Regulations (1996) and EN 1829: High pressure cleaners, High pressure water jet machines-Safety requirements. The safety aspects to be addressed relating to jetting are, practices concerning high pressure water, possible infection from the drain contents, working on the highway and in some circumstances, working in confined spaces.

### Equipment

9. Jet heads with nozzles set at approximately  $20^\circ$  to the pipe surface have a low jet angle and are unlikely to cause damage to the pipeline. Fan jets have low jet angles and are widely dissipated and hence unlikely to cause damage to the pipeline.

## HMEP CL 570 AR - REINSTATEMENT OF FAILED CHAMBER COVERS AND GULLY GRATINGS

### General

1. Reinstatement of failed chamber top and gully grating installations, or necessary raising because of pavement reconstruction or overlays, shall be subject to the following considerations:
  - (a) It is likely that all work, from removal of the unit(s) to completion of reinstatement, will have to be carried out against strict time constraints in order that a partial or complete road closure can be lifted and the road reopened to traffic;

- (b) The frame supporting structure may have deteriorated, may not meet requirements, or may be damaged during removal of the unit and/or any surrounding pavement material;
  - (c) It may not be a realistic proposition, because of time constraints, to limit the thickness of bedding material to the range permitted within this Specification;
  - (d) It may not be possible, because of constraints, to reinstate pavement surround materials in the layered construction preferred in Volume 7 of the DMRB;
  - (e) Re-use of frames and covers shall require the approval of the Overseeing Organisation;
  - (f) Any of the above considerations may warrant a departure from the standard and will, therefore, need the approval of the Overseeing Organisation.
2. The following supplementary requirements are comprehensive in that they apply to installations located in pavement constructions such as carriageways, hard shoulders, hard strips, and possibly central reservations. This will always be the case with gully gratings, although chamber tops may not be located within paved areas of the highway. The recommended procedures shall be amended to suit specific site requirements. Where no loading will take place frames for chamber covers and gratings, including soakaway covers, may be bedded on mortar designation (i).

### Removal of Existing Installation

3. Any necessary traffic management shall be carried out in accordance with Chapter 8 of the Traffic Signs Manual. In Northern Ireland on roads other than Motorways and Dual Carriageways with hardshoulders, Traffic Management is carried out in accordance with the Code of Practice for Safety at Street Works and Road Works. Times likely to cause least disruption to traffic are night times, Sundays or between 10am and 3pm during weekdays. Prior to examining and determining remedial work on a failed installation, it shall be established whether or not a reinstatement to its original full standard is a necessity. It may, for example, be possible to accept a reduced standard of reinstatement such as provision of a non-personnel standard of access, or even in extreme cases, slabbing-over of the chamber if sufficient consequential benefits such as reduced traffic disruption or future reduced maintenance are likely to be a consequence.
4. The cover shall be eased using a mechanical lifting device if necessary, but not removed from the frame. Cover hinge bolts shall not be removed.
5. The position of cuts to be made through pavement layers in order to enable removal of the frame shall be marked. These cuts shall be located at a minimum distance of 200 mm away from the estimated outside edges of the frame. If any cracks or signs of failure in the pavement materials extend beyond this distance, the cut positions shall be adjusted such that they are at least 50 mm beyond the extent of any such cracking.

6. The full depth of any bound layers of pavement construction around the frame shall be cut through with a circular saw or similar apparatus. Material between the position of the cut and the frame shall be removed to reveal the frame and the full width of the chamber wall along all edges.
7. The cover(s) shall be extracted using a mechanical lifting device or lifting keys with long shanks. The handles of such keys shall be at approximately waist height in order to reduce the risk of injury. The Manual Handling Operations Regulations 1992 must be observed.
8. The frame shall be lifted to reveal the bedding material beneath. This shall involve at least two people and be in accordance with Health and Safety Executive (HSE) 'Manual Handling, Guidance on Regulations'.

### **Re-use of Existing or Provision of New Cover and Frame**

9. The cover and frame shall be examined to assess whether it is of adequate specification for re-use, and if so, whether it is in a sufficiently fit condition. If either cover or frame is unfit for re-use, the complete unit must be replaced. A frame which has been previously bedded on a polyester resin material will be unfit and shall be replaced. A sharp hammer tap will usually be sufficient to remove any cementitious bedding material which may still adhere to the underside of a frame. All old bedding material, loose paint, rust and other debris shall be cleaned off the whole of the frame using a wire brush and scraper. The use of new covers in old frames shall not be permitted.

### **Frame Supporting Structure**

10. The frame supporting structure shall be inspected for structural integrity. Dependent upon the availability of specially trained and equipped staff and e.g. the age of the structure, it may be beneficial to inspect both the cover slab and also the underlying chamber at the same time.
11. All old bedding material must be carefully removed. For safety reasons, this work shall be carried out from road surface level unless operatives can stand on the base of the chamber with heads well above ground level. Care must be taken to avoid dropping loose materials into the shaft as this can result in pipe blockages or damage to apparatus, pipes or cables.
12. Operatives entering manholes shall ensure that they act in accordance with the Management of Health and Safety at Work Regulations 1999 and the Confined Spaces Regulations 1997. Particular care must be taken to avoid damaging any apparatus, pipes or cables when standing, entering or leaving.
13. If the previous bedding material was a polyester resin type it will be necessary to remove the underlying top course of the frame supporting structure and rebuild the structure as necessary to suit the depth of reconstruction. The supporting structure must be of adequate size and strength to support the frame, cover and expected loading. The surface of the supporting structure must have adequate strength to resist

the imposed loading. If the structure is brickwork, all joints must be full and pointed. All inadequate or unsound portions of the structure must be removed and newly exposed surfaces cleaned and prepared for reconstruction.

14. Reconstruction must be undertaken in accordance with the requirements of this Specification. The bedding surface must permit a bedding thickness of between 10 mm and 75 mm. If rebuilding involves more than one course of brickwork or precast concrete cover frame seating ring, an adjusting course may still be necessary consequential to a revised finished surface level.
15. Frame supporting structure reconstruction must be in Class B Engineering bricks or precast cover frame seating rings, laid with a proprietary cementitious mortar which will develop a compressive strength of not less than  $20\text{N/mm}^2$  prior to trafficking, and has a workable life of between 1 and 2 hours. Brickwork corbels must be constructed in bricks without holes or frogs.

### Re-bedding of Covers/Gully Gratings

16. The depth of reconstruction must be measured, bearing in mind that this may vary at different parts of the frame where the installation is within the camber of a road pavement. The bedding material must be in accordance with sub-clause 18 to 23 of this Clause, and compatible with the required thickness of application. Mixing and placing must be as described in sub-clause 24 to 26 of this Clause.
17. Bedding layers greater than 50 mm thick shall be laid in two stages. The first layer shall be no thicker than 40 mm and must be covered with a proprietary packing material whilst the mortar is workable. Uniform contact between materials is necessary in a composite bedding layer, and the proprietary packing material shall be tamped down to ensure even contact with the bedding. Placing of frame and cover shall be as set out in sub-clause 27 to 32 of this Clause.

### Bedding Materials

18. Chamber tops and gully tops shall be bedded upon bedding material which has the following properties:
  - (a) the material shall be non-shrink. Use of other materials may be considered in consultation with the Overseeing Organisation;
  - (b) the material shall have a minimum workable life of 15 minutes;
  - (c) the compressive strength of the material shall exceed  $30\text{N/mm}^2$  in 3 hours (Test Method in accordance with BS 6319: Part 2);
  - (d) the tensile strength of the material shall exceed  $5\text{N/mm}^2$  in 3 hours (Test Method in accordance with BS 6319: Part 7);
  - (e) notwithstanding the above requirements, the use of proprietary bedding components to different specifications may be permitted subject to appropriate certification and approval from the Overseeing Organisation;

19. This specification is for a rapid-hardening material which could, for example, be achieved by a suitable resin based material. The use of alternative bedding compounds to different specifications is not necessarily precluded where they form part of an alternative proprietary support system which has the approval of the Overseeing Organisation.
20. Bedding materials shall be laid strictly in accordance with the manufacturers' recommendations. Materials manufactured for use in different temperature conditions must be selected as appropriate to suit site conditions at the time of mixing and application. Thickness of materials must be within the range stipulated by the manufacturer.
21. Packing materials described below may be incorporated within the bedding material provided that this is in accordance with recommendations of the mortar manufacturer and the requirements of this Specification.

### **Packing Materials**

22. Packing materials have historically been used, particularly where it has been necessary to raise the finished levels of chamber tops and gully tops, whilst retaining the existing frame supporting structure, e.g. because of pavement overlays or strengthening works.
23. The permitted use of packing materials shall be as described in Appendix 5/1. Such materials shall be proprietary and purpose-made of suitable materials. The Contractor shall ensure that the proposed packing materials are compatible with the bedding material which it is intended to use. The use of materials such as quarry tiles and slates as packing materials is not permitted.

### **Mixing and Placing the Bedding Layer**

24. Mechanical mixing of the materials is preferred, although manual mixing is permitted. The maximum quantity to be mixed by each method shall not exceed 50 kg and 25 kg respectively. In cases where cementitious materials are used the manufacturer's recommended water content must be used.
25. The bedding material must be placed on the chamber immediately after mixing. It shall be placed at a depth approximately 5 mm greater than the required bedding thickness and spread across the full width of the chamber wall. Deep trowel marks in the bedding shall be filled and the surface of the bedding floated to an approximately even finish.

### **Thermo-Setting Polymer Resin Materials**

26. There are a number of issues which must be borne in mind when working with thermo-setting polymer resin materials:
  - (a) Care is required in their safe handling. Harmful vapours may be produced during mixing and the use of gloves, goggles and barrier creams is

- recommended by manufacturers. Some products are available in different grades to suit different temperature conditions in order to provide the necessary time of initial set, and such products shall be selected accordingly;
- (b) They remain at the same level of workability prior to setting, but the set is usually very rapid and early strengths develop quickly. Bedding of the frame must take place promptly after placement of the bedding material;
  - (c) They form a strong bond with contiguous materials, but the bond may be severely impaired if the surfaces are not kept clean and dry. Site conditions may dictate the need to take extra precautionary measures in keeping the surfaces clean and dry. Tools must be cleaned before the material sets. More importantly, frames which have been bedded on polyester resin which has set may not be separable from the resin. Removal of frames in such situations will also damage the frame supporting structure;
  - (d) Once set, the material becomes inert, and is not a toxic waste;
  - (e) Unmixed material must be mixed and disposed of with care according to Control of Substances Hazardous to Health Regulations (COSHH) Regulations, and strictly in accordance with the manufacturers' recommendations.

### Placing of Frames and Covers

27. The frame shall be lowered onto the bedding as soon as possible, preferably using a mechanical lifting device rather than by solely manual means, in accordance with Health and Safety requirements.
28. The frame must be placed on the bedding so that all webs of the frame are fully supported by the frame supporting structure. The webs must not overhang the internal faces of the frame supporting structure. There must be no voids in the bedding beneath the frame. Special care must be taken in the vicinity of the cover seatings.
29. The frame must be carefully tamped down to the required level and slope. This can be achieved to the Specification requirements by placing a straight edge over the frame webs and surrounding carriageway or other level control points as appropriate.
30. Any holes within the frame must be infilled with bedding material and the flanges of the frame enveloped by a minimum thickness of 10 mm of the same material. A greater thickness may be applied provided that sufficient depth is left available for placement of any surfacing layers. Such application can be an effective use of any surplus material from the main bedding mix.
31. Exposed surfaces of the bedding around the outside of the frame must be floated to fill any voids and remove any loose fragments, and the exposed surface of the bedding material inside the chamber must be pointed to a smooth finish.
32. The cover shall be placed in the frame by a mechanical lifting device, or lifting keys with long shanks, after the bedding material has sufficiently set.

33. The frame shall not be exposed to any load or disturbance until the bedding material has attained a strength of 20 N/mm<sup>2</sup>.

#### Reinstatement of Surrounding Flexible Carriageway

34. The cover shall be placed in the frame, preferably using a mechanical lifting device, and reinstatement shall then be undertaken as set out in Chapter 3 of HD 31 'Maintenance of Bituminous Roads' (DMRB 7.4), but subject to the following additional requirements:
- (a) the cover and frame shall not be exposed to any load or disturbance until the bedding material has attained sufficient strength;
  - (b) care must be taken to avoid contact between any compaction device and the frame or cover in order to avoid damaging the frame or cover or the bedding layer;
  - (c) if the foot or plate of mechanical compaction equipment will not fit between the frame and the sides of the excavation at all levels, a self-setting fill material shall be used, which is compatible with the bedding material;
  - (d) self-setting fill material shall be placed no higher than 40mm beneath the finished surface level, in order to allow placement and thorough compaction of a permanent wearing course. Some materials may require the use of a bonding agent;
  - (e) after installation the frame and cover shall be flush with the road surface;
  - (f) the joint between the reinstated and existing materials shall be sealed with bituminous material.

#### Reinstatement of Surrounding Rigid Carriageway

35. The cover shall be placed in the frame, and reinstatement shall then be undertaken as far as possible in accordance with Chapter 4 of HD 32/94 'Maintenance of Concrete Roads' (DMRB 7.4.2), subject to the following considerations:
- (a) where possible a waterproof membrane shall be reinstated;
  - (b) the installation shall not be exposed to any load or disturbance until the bedding material has attained sufficient strength;
  - (c) concrete shall be placed and compacted to the required level, with any reinforcement at the appropriate position. There shall be no adverse reaction between the concrete and the bedding material, and the surface of the concrete shall be textured as required;
  - (d) if a preformed joint filler has been used, the groove shall be sealed in accordance with the sealant manufacturer's instructions;
  - (e) after installation the frame and cover shall be flush with the road surface

## HMEP NG 522 AR - REINSTATEMENT OF FAILED CHAMBER COVERS AND GULLY GRATINGS

### Introduction and Scope

1. Guidance on chamber tops, gully tops and their bedding requirements is set out in the Manual of Contract Documents for Highway Works (MCHW) 1, 2 and 3 and other documents of the Design Manual for Roads and Bridges (DMRB) Volumes 4 and 7. Location of chambers in carriageways, hard strips, hard shoulders and central reservation crossovers should not normally be permitted. However, this may occur in some circumstances, and in non-trunk road situations may be inevitable. Guidance on recommended procedures for installation prior to Advice Note HA 104/09 (DMRB 4.2.5) was set out in 'Preferred Method 7 – Adjustment of Street Ironwork, Cornwall County Council, 1985, developed by the Department of Transport Standing Committee on Highway Maintenance'.
2. The premature failure of chamber top and gully top installations has been shown to be a major contributory factor to the annual maintenance budget of UK roads. These failures are not usually of the frame and cover itself but of the supporting system and the pavement surface, generally flexible, immediately adjacent to the installation. Rocking of the frame and cover in failed installations can occur under traffic, causing noise pollution and potential hazard to vehicles.
3. Recent research has highlighted and confirmed that premature failure in the bedding material is one of the main factors contributing to poor performance of chamber top and gully top installations. It has been shown that conventional materials, procedures and material specifications have become superseded by more recent developments, and results of the research have led to an improved specification for the bedding material and improved frame and cover designs.
4. This Specification sets out procedures and advises on materials which will provide the best possible performance of road chamber top and gully top installations located within a carriageway. Its recommendations may be applied to other roads and traffic conditions, as appropriate.
5. This Document supersedes advice given in Preferred Method 7, and complements all relevant guidance and standards provided in MCHW and DMRB.

### Definitions

6. 'Work Area' - The space necessary to carry out the work safely.
7. 'Mechanical Lifting Device' - Equipment capable of lifting and lowering the frame vertically and moving it away from the chamber opening.
8. 'Temporary Frame Support Device' - Adjustable mechanical device used to support

the frame at a pre-determined level until the bedding has reached the required strength.

9. 'Adjusting Course' - A course of non-standard thickness necessary to bring the frame supporting structure to the correct bedding surface level.
10. 'Bedding Surface' - Upper level of the frame supporting structure upon which the frame bedding material is placed.
11. 'Bedding Depth' - Distance between the underside of the frame and the bedding surface.
12. 'Bedding Material' - Mortar bound by cement or other synthetic materials.
13. 'Failed Installation' - An installation of a cover and frame which comprises an access point to an underlying chamber upon which the frame is bedded, and which requires attention because of a structural failure or loosening of either the cover, the frame, or the supporting structure of the underlying chamber. Disturbance of the pavement immediately adjacent to the installation is often associated with such failures. An installation may be judged to have failed not only because of an apparent structural failure, but also when rocking has developed under trafficking such that unacceptable consequential noise levels have developed.
14. 'Proprietary Packing Material' - Purpose made packing material specifically manufactured to be used, and to be compatible with, the material to be used in bedding the frame of a chamber top or gully top upon the frame supporting structure.
15. 'Frame Supporting Structure' - Permanent brick and/or concrete structure which supports the frame and any additional loading.
16. 'Depth of Reconstruction' - Depth from the top of the new bedding surface down to the top of the first undisturbed course of the existing frame supporting structure.
17. 'Finished Surface Level' - The required levels and crossfall to which the top of the frame and cover is to be set.
18. 'Self Setting Fill Material' - Material designed to achieve the required strength without mechanical compaction.
19. 'Frame Bearing Area' - The surface of the underside of the frame which rests upon the supporting structure.
20. 'Nominal Bearing Pressure' - The bearing pressure calculated by dividing the test load (BS EN 124) by the Frame Bearing Area (see 2.14).

**DESIGN CONSIDERATION FOR CHAMBER TOPS AND GULLY TOPS****General Requirements**

1. Chamber tops and gully tops shall be specified in accordance with BS EN 124:1994 'Gully Tops and Manhole Tops for Vehicular and Pedestrian Areas – Design Requirements, Type Testing, Marking, Quality Control'.

Access covers with clear opening of greater than 1m shall comply with BS 9124:2008 'Specification for steel and aluminium access covers systems with over 1m clear opening'.

2. The minimum Classification for all chamber tops and gully tops installed in areas of carriageway that are likely to be subject to traffic, either directly or indirectly, shall be D400 of BS EN 124.
3. The installation of higher category covers and frames such as E600 should be considered in applications where the chamber is located in the wheel path of a carriageway carrying over 1,500 commercial vehicles per day in each direction. Such proposals should be discussed with the Overseeing Organisation. It should be noted that EN 124 is a minimum performance specification and if there is any doubt, a higher category cover and frame should be selected.
4. Where chamber tops are likely to be subject to trafficking, including vehicles, cyclists, pedestrians or equestrians, covers proven to provide an adequate level of skid resistance shall be selected. Measurement of in-service skid resistance potential shall be by means of a Polished Skid Resistance Value (PSRV) in accordance with BS 9124.

Alternatively, direct measurements made on similar covers in similar conditions of use can be used as an indication of expected levels of in-service performance.

An unpolished test value (USRV) will not necessarily indicate the in-service skid or slip resistance of a cover and as such may give rise to safety concerns.

For sites carrying predominantly pedestrian traffic, cyclists or equestrians a value of not less than PSRV 45 for average or low risk sites or PSRV 60 for potentially high risk sites should be specified. The Unpolished Skid Resistance Value (USRV) is not an acceptable alternative.

Site risk is defined by the following:

- (i) Potentially High Risk includes:
  - (a) traffic signals, pedestrian crossings and railway level crossings including 50 m approaches;
  - (b) roundabouts and their exits, including 50 m approaches;
  - (c) bends < 100 m radius where the speed limit > 40 mph (65 km/h),

including 50 m approaches;

- (d) downhill gradients > 10% for more than 50 m (single or dual carriageway);
  - (e) uphill gradients > 10% for more than 50 m (single carriageway only).
- (ii) Average or Low Risk is applied to all other situations on single and dual carriageways:
- (a) including generally straight sections of carriageway;
  - (b) approaches to and across major/minor road junctions;
  - (c) bends of 100 m radius or greater, at any speed limit;
  - (d) downhill/uphill sections of 10% gradient or less.

### Certification Requirements

5. All chamber tops and gully tops shall be certified by one of the accepted United Kingdom Accreditation Service (UKAS) accredited certification bodies as listed in Appendix B of Volume 1 of the MCHW, or alternative product conformity certification schemes subsequently accepted by the Overseeing Organisation.

6. Alternative product conformity certification schemes should meet the equivalence requirements contained in Series 100 of the Specification for Highway Works (SHW) (MCHW1). The Overseeing Organisation requires compliance with the following:

- (a) Products should have been designed, developed and manufactured within a BS EN ISO 9001 system that has been assessed by a relevant recognised accredited certification body. In the UK the certification body must be accredited to EN 45011 by UKAS.

Certificates issued against BS EN ISO 9001 must include design and development within the scope where appropriate.

- (b) Products should have been type tested by a UKAS accredited or UKAS accepted third party testing organisation that has accreditation to BS EN ISO/IEC 17025 and BS EN 124 within its scope. Assessment must be made by an organisation with accreditation to BS EN ISO/ IEC 17021.
- (c) Product conformity certificates to BS EN 124 should have been issued to the manufacturer of the chamber tops or gully tops by a UKAS accredited certification body. The certification body must have both EN 45011 and EN 45012 within its scope.
- (d) The certification process should have been overseen or audited by a single relevant accredited certification body.

**DESIGN REQUIREMENTS: CHAMBER TOPS**

1. A chamber cover for man-entry purposes should conform with the following minimum clear opening requirements:
  - (a) the minimum clear opening for a frame with a rectangular opening should be 600 mm with a diagonal measurement of not less than 700 mm;
  - (b) the minimum clear opening for a frame with a circular opening should be a diametric measurement of not less than 700 mm.
2. A larger opening may be specified if it is considered appropriate because of considerations of chamber depth or necessary access which may involve the use of personnel wearing breathing apparatus. Guidance on minimum cover dimensions where personnel access is not required is included in BS EN 752-3.
3. The frame and cover should be silent and stable when trafficked. Notwithstanding the advice given in paragraph NG 5X1.1 the frame should normally be at least 150 mm deep for installations in trafficked carriageways. The depth of the insertion of the cover within the frame should be not less than 50 mm, or not less than 80 mm if the design relies upon the depth of insertion for security.
4. Where couplings, either fixed or loose, are present as a design feature in the casting, then loose couplings should be of steel or spheroidal graphite cast iron (ductile iron). If bolts are used as couplings in chamber covers, they should comply with BS 4190, be of no less than M16 grade and be hexagon headed complete with hexagon nuts. Other types of loose couplings should have a minimum cross-sectional area of 140 mm<sup>2</sup>. Any pins or circlips used as part of the securing device should be of equal cross section or be sufficiently protected to give equivalent performance. Any loose coupling should not be able to vibrate free during its service life. Fixed couplings must be made of the parent metal.
5. Vents are not required in chamber tops unless specified.
6. Seatings of covers within frames are to be manufactured in such a way as to ensure that stability and quietness are achieved when trafficked without periodic maintenance/replacement of any cushioning inserts. Sealing of covers within frames is not required unless specified in Appendix 5/1 of the Specification for Highway Works (MCHW 1).
7. The frame bearing area should be designed in such a way that:
  - (a) the nominal bearing pressure in relation to the test load (BS EN 124) should not exceed 2.1N/mm<sup>2</sup>;
  - (b) frames should have an overall minimum bedding width of 50 mm of metal. It is considered desirable to limit the maximum overall bedding width to 120 mm of metal;

- (c) for openings with corners, external corners of the frame should be solid (unless it can be demonstrated to the Overseeing Organisation that the inclusion of holes does not reduce the structural integrity of the system) and may be square, curved or chamfered but at no point should the width be less than the minimum bedding width.
8. The bedding flange should have a minimum thickness of 5 mm. Where vertical frame stiffening webs/gussets are provided, they should be located adjacent to seatings. The tops of such triangular webs/ gussets should be as permitted in BS 7903.
  9. Frames weighing more than 15 kg should be provided with suitable lifting holes located to permit a balanced lift and should be marked accordingly.
  10. Frames should not contain holes within the seating areas of the bedding flanges beneath the cover seatings. Any holes within the bedding area of the frame should be minimal and should not reduce the specified bearing area of the frame.
  11. Preference should be given to designs which are ergonomic in accordance with the Management of Health and Safety at Work Act to facilitate safe removal of the cover (e.g. keyholes, slots, etc.).
  12. Notwithstanding the above requirements, the use of alternative support systems to different specifications may be permitted subject to appropriate certification and approval from the Overseeing Organisation.

#### DESIGN REQUIREMENTS: GULLY TOPS

1. Gully tops shall be to BS EN 124 and in accordance with clauses 3.2 and 3.3 of this document.
2. Gully gratings and frames shall be made from suitable material as specified in BS EN 124. Hinged gratings may be either kerb hinged or side hinged appropriate to the direction of traffic flow.
3. Nominal widths of gratings and minimum areas of waterway shall be in accordance with BS EN 124 and BS 7903. UK practice is that the minimum area of waterway should be 900 cm<sup>2</sup>. Of the total waterway area, there should be a minimum waterway area of 45 cm<sup>2</sup> between the kerb face of the frame and a parallel line 50 mm distant, and there should be a minimum waterway area of 65 cm<sup>2</sup> between the kerb face of the frame and a parallel line 90 mm distant. The frame should be at least 100 mm deep.
4. Kerb-type gully covers and frames, if required, should provide a kerbside water intake and an access cover which, if hinged, should open away from the carriageway i.e. towards the kerb. Weir depth, i.e. the distance from the top of the cover to the top of the fixed weir, if any, should be 115 mm (Type 1) or 165 mm (Type 2) as specified. Kerb-type gully covers and frames should be provided with a Type HB (half batter) profile to BS 7263: Part 1, unless otherwise specified. The

critical dimensions of kerb-type gully covers and frames taken from BS 7903 are shown in the following table:

5. Interruptions to weir length and cleaning area, produced by debris trap features should not reduce the minima specified within the table.
6. Kerb type gully covers and frames should also comply with the following requirements:
  - (a) a metal retaining bar, of minimum cross-section 35 mm x 25 mm for use during construction should be provided. It should be supplied loose so as to allow adjustment to suit the required road level;
  - (b) the access cover should be provided with either open keyway(s) or a locking mechanism. An opened unit should provide a minimum rectangular clear opening of 400 mm x 250 mm.

Where a cover can be readily raised without the use of the key or other tool, a locking mechanism should be provided. Where a hinge is provided this should be at the rear edge of the cover, as viewed from the road. The top shall be self draining and have a raised pattern conforming with BS EN 124;

- (c) a grid with horizontal bar(s) of a minimum diameter of 12 mm, galvanised in accordance with BS 729 or a minimum of two integrally cast vertical fins should be provided to act as a debris trap across the open mouth of the unit.

#### KERB-TYPE GULLY COVERS AND FRAMES

Table NG 522 AR Weir Length and Waterway		
Reference	Type 1	Type 2
Weir Depth (mm)	115	165
Minimum net weir length (mm)	425	425
Minimum rectangular clearway (cm <sup>2</sup> )	250	250
Minimum rectangular clear opening (mm)	400 x 250	400 x 250
<b>Note:</b> Weir depth is distance from the top of the cover to the top of fixed weir.		

## SERIES 700 - ROAD PAVEMENTS - GENERAL

Following review of the information provided by the contributing local authorities it became apparent that alterations to the Manual of Contract Documents for Highways Works and Specification for Highways Works for Series 700 – Road Pavement were limited, and intermixed with Series 900 – Road Pavement Bituminous Bound Materials.

It appeared that where alterations to the Manual of Contract Documents for Highways Works and Specification for Highways Works for Series 700 were specified it may have been as part of an individual project that had been carried forward by default into a general specification. For the purposes of the project these were considered in light of their possible provenance and a judgement on their use taken. It is considered that there is insufficient evidence to justify alteration to the existing Series 700 Clauses to the Manual of Contract Documents for Highways Works and Specification for Highways Works.

The following contents list, lists the current Clauses from the Specification for Highways Works for Series 700 – Road Pavements – General. No alternate HMEP Clauses are proposed.

### Contents List

Series 700 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
701	(05/02) Pavement Construction	-	-
702	Horizontal Alignments, Surface Levels and Surface Regularity of Pavement Courses	-	-
706	(05/01) Excavation, Trimming and Reinstatement of Existing Surfaces	-	-
707	Breaking Up or Perforation of Redundant Pavement	-	-
709	(05/01) Cold-milling (Planing) of Bituminous Bound Flexible Pavement	-	-

Table Continued			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
710	(11/04) Testing for Constituent Materials in Recycled Aggregate and Recycled Concrete Aggregate	-	-
711	(05/01) Overband and Inlaid Crack Sealing Systems	-	-
712	(05/01) Maintenance of Arrester Beds	-	-
713	(05/01) Saw-cut and Seal Bituminous Overlays on Existing Jointed Concrete Pavements	-	-
714	(05/01) Preparation of Jointed Concrete Pavements Prior to Overlaying and Saw-cut and Seal of the Bituminous Overlays	-	-
715	(05/01) Saw-cut, Crack and Seat Existing Jointed Reinforced Concrete Pavements	-	-
716	(11/07) Cracking and Seating of Existing Jointed Unreinforced Concrete Pavements and Hydraulically Bound Mixture (HBM) Bases	-	-
717	(11/07) Monitoring of Cracked and Seated Jointed Unreinforced Concrete Pavements and HBM Bases Using the Falling Weight Deflectometer (FWD)	-	-
718	(11/07) Monitoring of Saw-cut, Cracked and Seated Jointed Reinforced Concrete Pavements Using the Falling Weight Deflectometer (FWD)	-	-
719	(11/07) Back-analysis of Falling Weight Deflectometer (FWD) Measurements Made on Concrete Pavements Treated by Fractured Slab Techniques	-	-

**Example Appendix 7/1**

An example Appendix 7/1 is included under Series 900. It has been prepared to illustrate the use of materials in various categories of highway from highly trafficked dual carriageway to farm access tracks.

## SERIES 900 – ROAD PAVEMENTS BITUMINOUS BOUND MATERIALS

Of the total number of variations to the existing Manual of Contract Documents for Highways Works and Specification for Highways Works received from contributing authorities over 28% related to bituminous materials, indicating the probable need for standardisation of these items. From the specification examples provided it was found that, although there were a number of variations from the Manual of Contract Documents Specification for Highways Works standard clauses, these could be attributed to the desire of the authority to update their individual specification to match current developments or guidance on the subject. Guidance notes from the Highways Agency have been examined from the date of release of the original clause, and specifications examined to provide the best material options for local authority highway maintenance works. Material specifications have been designed to maximise the service life of the material, while taking into account developments in low-carbon alternatives and carbon capture, and sustainable options such as recycled aggregates.

Consultation has also been undertaken with industry groups , Asphalt Industry Alliance, Road Surface Treatments Association and with the ADEPT Soils and Materials Sub-Group who have provided valuable comments on the development of the following Clauses.

The contents list below lists the current Clauses from the Specification for Highways Works and alternate Clauses developed by the HMEP for local highways authority use.

### Contents List

Series 900 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
901	(08/08) Bituminous Pavement Mixtures	-	-
902	(08/08) Reclaimed Asphalt	-	-
903	(08/08) Placing and Compaction of Bituminous Mixtures	903 SR	Placing and Compaction of Bituminous Mixtures
904	(08/08) Hot Rolled Asphalt Base	-	-
905	(08/08) Hot Rolled Asphalt Binder Course (Recipe Mixtures)	-	-

<b>Table Continued</b>			
<b>Clause Number</b>	<b>Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works</b>	<b>HMEP Clause Number</b>	<b>Highways Maintenance Efficiency Programme</b>
906	(08/08) Dense Base and Binder Course Asphalt Concrete with Paving Grade Bitumen (Recipe Mixtures)	-	-
907	(08/08) Regulating Course	907 SR	Regulating Course
909	(08/08) 6 mm Dense Asphalt Concrete Surface Course	-	-
910	(08/08) Hot Rolled Asphalt Surface Course (Recipe Mixtures)	-	-
911	(11/08) Hot Rolled Asphalt Surface Course (Design Mixtures)	-	-
912	(08/08) Close Graded Asphalt Concrete Surface Course	-	-
914	(08/08) Fine Graded Asphalt Concrete Surface Course	-	-
915	(08/08) Coated Chippings for Application to Hot Rolled Asphalt Surfacing	-	-
916	(08/08) Open Graded Asphalt Concrete Surface Course	-	-
918	(08/08) Slurry Surfacing Incorporating Microsurfacing	-	-
919	(08/08) Surface Dressing: Recipe Specification	-	-
920	(08/08) Bond Coats, Tack Coats and Other Bituminous Sprays	-	
921	(08/08) Surface Macrotecture of Bituminous Surface Courses	921 SR	Surface Macrotecture of Bituminous Surface Courses

<b>Table Continued</b>			
<b>Clause Number</b>	<b>Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works</b>	<b>HMEP Clause Number</b>	<b>Highways Maintenance Efficiency Programme</b>
922	(08/08) Surface Dressing: Design, Application and End Product Performance	-	-
924	(08/08) High Friction Surfaces	-	-
925	(08/08) Testing of Bituminous Mixtures	-	-
926	(08/08) Insitu Recycling: The Repave Process	-	-
929	(08/08) Dense Base and Binder Course Asphalt Concrete (Design Mixtures)	-	-
930	(08/08) EME2 Base and Binder Course Asphalt Concrete	-	-
937	(08/08) Stone Mastic Asphalt (SMA) Binder Course and Regulating Course	-	-
938	(08/08) Porous Asphalt	-	-
942	(08/08) Thin Surface Course Systems	-	-
943	(08/08) Hot Rolled Asphalt Surface Course and Binder Course (Performance-Related Design Mixtures)	943 SR	Hot Rolled Asphalt Surface Course and Binder Course (Performance-Related Design Mixtures)
945	(08/08) Weather Conditions for Laying of Bituminous Mixtures	-	-
946	(08/08) Patching and Repairs to Potholes and Depressions (Including Emergency Patching)	946 SR	Patching and Repairs to Potholes and Depressions (Including Emergency Patching)
947	(08/08) Insitu Cold Recycled Bound Material	-	-

Table Continued			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
948	(08/08) Ex Situ Cold Recycled Bound Material	-	-
950	(08/08) Surface Preservation Systems	-	-
953	(08/08) Durability of Bituminous Materials -Saturation Ageing Tensile Stiffness (SATS) Test	-	-
954	(08/08) Method for Laboratory Determination of Interface Properties Using the Modified Leutner Shear Test	-	-
955	(08/08) Binder Recovery Using the Rapid Recovery Test (RRT) and Accelerated Ageing Using the Modified Ageing Rolling Thin Film Oven Test (RTFOT)	-	-
956	(08/08) Determination of the Complex Shear (Stiffness) Modulus ( $G^*$ ) and Phase Angle ( $\delta$ ) of Bituminous Binders Using a Dynamic Shear Rheometer (DSR)	-	-
957	(08/08) Determination of Cohesion of Bitumen and Bituminous Binders	-	-
958	(08/08) Modified Binder Storage Stability Test	-	-
-	-	970 AR	Coloured Surfacing for Lane Demarcation
-	-	971 AR	Stress Absorbing Membrane Interlayer (SAMI)
-	-	972 AR	Stone Mastic Asphalt Surface Course
-	-	973 AR	Retread Process

## HMEP CL 903SR PLACING AND COMPACTION OF BITUMINOUS MIXTURES

### General

1. This clause gives general requirements for the placing and compaction of bituminous mixtures, which are complementary and additional to the requirements of BS 594987. These requirements and the requirements of BS 594987 apply to all bituminous mixtures, unless otherwise specified in the other Clauses in this Series or in Appendix 7/1.
2. Bituminous pavements shall be constructed using the materials specified in Appendix 7/1 and shall be laid by contractors that are registered to the BS EN ISO 9001 'Sector Scheme for the Laying of Asphalt Mixes' described in Appendix A.
3. In order to exclude moisture from interfaces and ensure full interlayer bonding, the surface of all bituminous materials shall be kept clean and uncontaminated. Unless agreed with the Overseeing Organisation, the only traffic permitted to run on the surface of bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a binder course is to be blinding or surface dressed, that is engaged on such surface treatment. If any surface becomes contaminated, it shall be made good by cleaning and, if this proves impracticable, by rectification in compliance with Clause 702.
4. Prior to placing bituminous material on any new or existing bound substrate, a bond coat or track coat shall be applied in accordance with Clauses 920 or 942, as appropriate.
5. Before work commences, the contractor shall submit a method statement to the Overseeing Organisation that includes:
  - i) Laying and compaction procedures for each layer – including paving speed and paved width; size, type and number of rollers; and number of roller passes.
  - ii) This joint formation procedure for each layer – including the location of longitudinal and transverse joints; and the method(s) of treating upstanding edges.

### Transporting

6. Hot bituminous mixtures shall be transported in accordance with the requirements of BS 594987 and shall remain covered whilst awaiting tipping.
  - i) Material for machine lay works shall be fully used within 4 hours of mixing at the coating plant.
  - ii) Material for hand lay works that is not likely to be fully used within two hours of mixing at the coating plant shall be transported in and used directly from a "hot box" type system. Notwithstanding this, the temperature limits stated in

BS 594987 shall be adhered to. The maximum time the material shall be allowed to stay in a “hot box” is 12 hours after which it shall be discarded. Prior to loading the “hot box” all unused material from previous loading shall be removed. On dual box systems care shall be taken to prevent cross contamination or intermixing of different materials. Thermostats on “hot box” type systems shall be fitted, set & maintained so as to ensure that the temperature shall not exceed 160°C.

## Laying

7. Hot bituminous mixtures, other than those specified under Clause 942, shall be laid in accordance with the requirements of BS 594987 and sub- Clauses 8 to 14 of this Clause. Surfacing specified under Clause 942 shall be laid in accordance with the requirements of that Clause and sub-Clause 8 to 14 of this Clause.
8. Wherever practicable, hot bituminous mixtures shall be spread, levelled and tamped by a self-propelled paving machine. The rate of delivery of material to the paver shall be regulated to enable the paver to operate continuously.
9. Hand placing of hot bituminous mixtures shall be restricted to the following circumstances:
  - i) For laying regulating courses of irregular shape and varying thickness.
  - ii) In confined spaces where it is impracticable for a paver to operate.
  - iii) For footways.
  - iv) At the approaches to expansion joints at bridges, viaducts or other structures.
  - v) For laying mastic asphalt.
10. Hand-raking of surface course material or the addition of such material by hand-spreading to the paved area, for adjustment of level, shall be restricted to the following circumstances:
  - i) At the edges of the layers of material and at gullies, manholes and other ironwork.
  - ii) At the approaches to expansion joints at bridges, viaducts or other structures.
11. The method of laying shall be such that the finished mat is free from dragging, tearing and segregation of the material.
12. When laying mixtures from more than one source, the mixtures shall have equivalent laying and compaction characteristics so that surface evenness is not compromised.
13. When paving adjacent to an expansion joint of a structure, the joint or joint cavity shall be kept clear of material. When laying binder course or surface course, the paver shall be taken out of use whilst laying the remainder of the pavement up to the joint and the corresponding area beyond it. This requirement has been based on practices

commonly used in asphalt construction for airfields. It may warrant future review if this requirement proves to be excessively onerous for highway contracts.

14. When paving directly onto bridge deck waterproofing systems, any special requirements which apply to that system shall be complied with.

**Compaction**

15. The adopted mix design must be optimised for mixture volumetrics (density and air voids), performance and durability. The compaction of hot bituminous mixtures shall be in accordance with BS 594987 but with sampling frequencies and target conforming to Table 903SR/1. These requirements are based on testing of road pavement cores and the requirement for footways shall refer to Table S10.1 of Specification for the Reinstatement of Openings in Highways (SROH). At locations where core removal is not desirable, a trial section of a dimension as approved by the Overseeing Organisation shall be constructed using the proposed construction plant to establish that the design material will meet the air voids requirements.

**Table 903SR/1 Compaction requirements (air voids of cores extracted from the road)**

Materials	Clause	Mean of any pair taken from the centre of the mat and/or at wheel-track lanes		Any single core taken from/adjacent to joints and/or unsupported edges
		Min %	Max %	Max %
Dense asphalt concrete	906 909 912	2	7	9
HRA	911 943AR	-	6	8
EME2	930	2	6	8
SMA	937 971AR	2	6	8
Thin surface course system	942	2	X + 1	X + 2
Permitted hand lay materials	-	2	8	10

Table 903SR/1 Compaction requirements (air voids of cores extracted from the road): continued				
Materials	Clause	Mean of any pair taken from the centre of the mat and/or at wheel-track lanes		Any single core taken from/adjacent to joints and/or unsupported edges
		Min %	Max %	Min %
Bridge deck surfacing	-	In accordance with IAN 96/07; asphalt layer directly overlaying the waterproofing system should have a design air void content of no more than 4%		
Non-BBA/HAPAS thin surfacing	-	Compaction level to be determined prior to use and agreed with the Overseeing Organisation		
Patching and repair materials	-	Compaction level in accordance with SROH (2010) or as agreed with the Overseeing Organisation		
Note: X denotes air void content achieved on the BBA/HAPAS trial or the Contractor's declared mix design after approval by the Overseeing Organisation.				

16. Except where otherwise specified, rollers shall comply with the general requirements of BS 594987 except that the minimum mass of deadweight smooth wheeled rollers shall be 8 tonnes. Multi-wheeled pneumatic-tyred rollers and vibratory rollers may be used if they are capable of achieving at least the standard of compaction of an 8-tonnes deadweight roller.
17. Where compaction is to be determined in accordance with Clauses 929 and 930, the requirements to prove the performance of rollers do not apply. In such cases, the Contractor may use any plant to achieve the specified level of compaction and shall finish compaction at temperatures above the minimum specified rolling temperature.
18. Vibratory rollers shall not be used in vibrating mode on bridge decks.

### Chippings

19. The application of coated chippings to areas of surface course shall be by a mechanical spreader capable of distributing chippings to an even rate of spread. Addition of chippings by hand operation shall only be permitted in the following circumstances:
  - a) In confined spaces, where it is impracticable for a chipping spreader to operate.
  - b) As a temporary expedient, when adjustments have to be made to the spreader distribution mechanism.

- c) When hand laying of the surface course is permitted.
  - d) To correct uneven distribution of chippings.
20. Chippings shall be applied uniformly and rolled into the surface so they are effectively held and provide the initial macrotexture depth specified in Clause 921.

### Joints

21. For new pavement construction, all longitudinal joints in all layers shall be situated outside wheel-track zones. Where an existing road pavement is resurfaced or reconstructed, joints in the surface course shall coincide with either the lane edge, the lane marking, or the middle of a traffic lane, whichever is appropriate. Joints shall not coincide with the wheel path. For the purposes of this Clause, the wheel-track zones shall be taken to be between 0.5 m and 1.1 m and between 2.55 m and 3.15 m from the centre of the nearside lane markings for each traffic lane (or, in the absence of lane markings, lane edges). All joints shall be offset at least 300 mm (where possible) from parallel joints in the layer beneath. For narrower roads, further adjustment may be proposed to the Overseeing Organisation.
22. Unless otherwise specified in Appendix 7/1, the faces of all cold upstanding edges, including previously laid asphalt, against which hot bituminous mixtures are to be laid to form joints shall be treated with one of the following:
- (i) hot bituminous binder with a penetration of not less than 40 pen;
  - (ii) hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen;
  - (iii) cold applied thixotropic bituminous compound of similar bitumen or polymer-modified bitumen grade;
  - (iv) polymer-modified adhesive bitumen strip with a minimum thickness of 2 mm.

This operation shall be done so that the binder adheres to both the cold and the warm upstanding edges when the asphalt is placed.

23. Unless otherwise specified in Appendix 7/1, joints in binder courses and bases shall be compacted such that the air voids content measured from core pairs whose centres are not more than 100 mm from the final joint is not greater than 2% above the maximum permitted limit for core pairs in the body of the mat. The air voids content shall be calculated in accordance with BS EN 12697-8 using the relevant bulk and maximum densities defined in Appendix B of BS EN 13108-20 for the relevant mixture type.
24. Within 24 hours of the joint being formed, a sealant shall be applied to the top surface of all base and binder course joints such that there is not less than 0.50 kg/m<sup>2</sup> of residual bitumen 75 mm either side of the joint, unless otherwise specified in Appendix 7/1. The sealant, which may contain mineral filler to BS EN 13043, shall be one of the following:

- (i) hot elastomeric polymer-modified bituminous binder complying with BS EN 14023 with a penetration of not less than 40 pen;
  - (ii) bitumen emulsion with a cohesion by pendulum of Class 4 or above in accordance with BS EN 13808;
  - (iii) slurry surfacing complying with Clause 918.
25. Unless otherwise specified in Appendix 7/1, a sealant, as specified in sub-Clause 24 of this Clause, shall be applied to the whole of any freestanding edge on the outside of the finished pavement on the high side of the camber and, when specified in Appendix 7/1, on the low side.

### Regulating Course

26. Regulating course material shall be made and laid in accordance with the requirements of Clause 907.

### Use of Surfaces by Traffic

27. Where a bituminous layer other than the surface course is to be opened to highway traffic as a temporary running surface it shall either:
- (i) be surface dressed in accordance with Clause 919 using chippings of category not less than PSV<sub>50</sub>, unless otherwise specified in Appendix 7/1; or
  - (ii) contain a coarse aggregate of category of not less than PSV<sub>50</sub>, unless otherwise specified in Appendix 7/1.
28. Construction plant and traffic used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the subgrade or the pavement courses already constructed. The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

## NG 903SR PLACING AND COMPACTION OF BITUMINOUS MIXTURES

### General

1. The purpose of this clause is to define the laying and compaction procedures that will maximise the durability of the finished pavement. It has been drafted to ensure compatibility with the general specifications for the transport, placing and compaction of asphalt mixtures given in BS 594987 and with other appropriate Clauses (929, 930, 942 and 945) and should always be read in conjunction with the above documents as they relate to the particular application.
2. Certain key factors are important in maximising the durability of the finished pavement and should be reviewed before work commences. These are:

- i) Mechanical laying wherever practicable.
- ii) Bonding of layers.
- iii) Good compaction, particularly at joints.
- iv) Pre-planning of compaction process.
- v) Sealing of edges and joints to prevent water ingress.

3. Clause 903 applies to the surfacing overlaying bridge decks but does not relate to laying waterproofing systems. When laying hot paving materials on bridge deck waterproofing systems, care must be taken to follow the guidance given in IAN 96/07. Appropriate measures should be taken to ensure that the bond system is fully activated by sufficient heat but that the waterproofing system is not damaged by excessive heat.

### Laying

4. Materials should be laid by paver unless there are small or inaccessible areas where hand laying is the only practicable method. Pavers should be used with the minimum of hand raking and making up. The use of automatic levelling devices should be encouraged and, where possible, greater emphasis should be given to evenness rather than levels, providing that pavement thickness and clearances at structures are achieved. This approach is particularly relevant when thick layers of base are being used to minimise the number of horizontal interfaces.
5. As far as practicable, the paver should work continuously without stopping. Stops can adversely affect the ride quality of the finished pavement. Therefore, there should be sufficient mixed material on site when paving commences to ensure that lack of supply will not stop operations. However, an excess number of delivery vehicles should also be avoided as it can result in congestion on site and an extended time between mixing and laying for each load.

### Compaction

6. It is important that an effective compaction plan appropriate to the site circumstances is in place and is understood by the paving crew. This is a requirement of sub-Clause 903.5.
7. There is no conclusive evidence to show all vibratory rollers provide consistently greater compaction than that achieved with conventional deadweight rollers. It is desirable that compaction should be maximised so site trials of vibratory rollers, proposed as an alternative to conventional deadweight rollers, may be beneficial. The trial should not only determine the required number of passes of the vibratory roller, but also the frequency and amplitude of the vibrating rolls and roller speed. Additional advice is included in TRRL Report LR 1102. Where evidence is provided by the Contractor to indicate a proposed vibratory roller will achieve adequate compaction, the evidence should be representative of the conditions likely to be

encountered in the Works. Factors which are relevant include types of compacted material and source of aggregate, the thickness and temperature of layers and the condition of the proposed roller compared with that previously used. Site trials are not required to prove vibrating rollers where the final density or air voids is measured as compaction is then a controlled parameter.

8. If compaction trials have been carried out, the frequency and amplitude of vibrating rollers and travelling speed of the roller which have been found to be satisfactory should be used. The Contractor can use equations [1] and [2], to select the paving and rolling rates to achieve the minimum number of roller passes required before the surfacing has cooled to the minimum temperature for compaction:

$$\text{Rolling length (m)} = \text{average paving speed}$$

$$(\text{m/min}) \times T (\text{min}) \dots [1]$$

$$\text{Roller passes} = (\text{Rolling rate/Paving Rate})$$

$$\times \text{No of Rollers} \dots [2]$$

where:

$$\text{Rolling rate (m}^2\text{/min)} = \text{Roller width (m)}$$

$$\times \text{Roller speed (m/min)}$$

$$\text{Paver rate (m}^2\text{/min)} = \text{Paver width (m)} \times$$

$$\text{Paver speed (m/min)}$$

T = time required for compaction (usually 10 min for HRA and 8 min for mixtures without pre-coated chippings)

9. When reliance is placed on a method specification for the control of compaction of bituminous mixtures, close attention should be paid to the temperature of the material. BS 594987 lays down minimum temperatures at which compaction should be substantially complete. It will, therefore, be necessary to commence rolling at temperatures exceeding the minimum, making due allowance for weather conditions, which may affect the rate of cooling of the laid material. NG 945 for cold weather working gives useful advice. For hot weather, TRL Report 494 'The Behaviour of Asphalt in Adverse Hot Weather Conditions' gives useful advice on the subject. For all practical purposes where material is tested for adequacy of compaction in accordance with Clauses 929, 930 and 937, the requirements should have been achieved above the minimum rolling temperature. Any subsequent rolling at temperatures below the minimum should only be necessary to remove roller marks and regulate the surface.

**Inter-layer Bond**

10. Inter-layer bond is essential to prevent ingress of water and resultant deterioration of the pavement. It is also important to ensure that the pavement acts as a homogenous structure. BS 594987 and Clause 920 give explicit and comprehensive requirements that should be followed. It is difficult to overestimate the importance of bond. Generally, it is good practice to lay bases in thicker lifts to minimise the number of layers and, hence, interfaces (giving due consideration to the maximum layer thicknesses given in BS 594987).

**Joints**

11. However a joint in a bituminous layer is constructed, it will always be the weakest part of the pavement. Therefore, it is good practice, wherever possible, to minimise the number of cold joints by, for example, using wide screeds and/or paving in echelon.

12. Joints should always be located in low stress areas of the pavement wherever practicable, as indicated in sub-Clause 903.21. However, where an existing road surface is being replaced, it is permitted to locate the longitudinal joints within the surfacing material in the middle of a traffic lane. This position should only be selected if positioning the joint under the lane edge or lane marking would result in significant areas of sound surface course material being unnecessarily replaced. Longitudinal Joints should never be placed in the wheel-track zones.

13. Compaction at joints with unsupported edges will never be as good as in the body of the mat. This is recognised in the air void content requirements in sub-Clauses 903.24, 929.15 and 930.15.

14. To guard against ingress of water at joints, Sub-Clause 903.22 requires binder to be applied to the vertical face prior to laying the adjacent mat in order to improve bond and Sub-Clause 903.25 requires overbanding to seal the surface of the joint.

15. To ensure that water does not enter the pavement from the side, sub-Clause 903.26 requires sealing the edges of the finished pavement. This is always required for the high side of the elevation. Sealing of the low side is conditional on whether it is necessary to let water out or stop water getting into the pavement. The selection is a design issue and should be specified in Schedule 4 of Appendix 7/1.

**HMEP CL 907SR REGULATING COURSE**

1. Regulating courses, which may consist of one or more layers of a bituminous material, shall have their finished surfaces laid to achieve the appropriate tolerances for horizontal alignments, surface levels and surface regularity for pavement layers, in accordance with Clause 702.

2. Unless otherwise specified in Appendix 7/1, stone mastic asphalt complying with Clause 937, or base or binder course asphalt concrete complying with Clause 929 or hot rolled asphalt complying with Clause 943, shall be used for regulating courses immediately below surface courses. Bituminous mixtures for regulating courses shall meet the requirements for the appropriate material, as specified above.
3. Unless otherwise specified in Appendix 7/1, the following materials shall be used for regulating courses:
  - i) AC 6 dense surf 100/150 (Clause 909)
  - ii) AC 10 close surf 100/150 (Clause 912)
  - iii) SMA 6 bin 100/150 (Clause 937)
  - iv) SMA 10 bin 40/60 (Clause 937)
  - v) SMA 14 bin 40/60 (Clause 937)
  - vi) HRA surf/bin (Clause 943AR)
4. The maximum and minimum compacted layer thicknesses for each regulating layer shall meet those recommended in BS 594987 for the selected material. Minimum regulating course thickness shall not be less than 15mm.
5. An increased thickness of the new binder course or base shall be applied in the situation where regulating course is required underneath a new overlay of binder course or base. A separate regulating course layer shall be avoided. Nevertheless, the maximum and minimum compacted layer thicknesses for the new binder course or base shall meet those recommended in BS 594987.
6. Regulating course mechanical properties shall be sufficient to support the overlaying material without compromising the durability and bearing capacity of the new overlay.

## NG 907SR REGULATING COURSE

1. Where a total depth of the new, increased layer thickness, overlay binder course or base exceeds the maximum compacted thickness permitted in BS 594987, this course shall be divided into thinner sub-layers. Permitted options for regulating course can be found in Table NG 907AR/1.

**Table NG 907AR/1 Permitted Options**

Thickness	Material
Less than 15mm	Not Permitted
15mm	A minimum layer thickness of 15mm of AC 6 dense surf 100/150 (Clause 909) shall be achieved by planing into the layer below.
15 – 30mm	AC 6 dense surf 100/150 (Clause 909) or SMA 6 bin 100/150 (Clause 937).
30 – 50mm	AC 10 close surf 100/150 (Clause 912), HRA bin (Clause 943AR) or SMA 10 bin 40/60 (Clause 937)

2. For durability reasons, the mechanical properties of the regulating course must be comparable with the overlying material. For example, a regulating course directly underneath a thin surface course system having Class 2 deformation resistance must also have a comparable deformation resistance.
3. An example of the requirements for construction materials in Appendix 7/1 is given in Table NG 907AR/2.

**Table NG 907AR/2 Appendix 7/1 Requirements for Regulating Course (Examples)**

909	6mm Dense Asphalt Concrete Surface Course	Mixture designation [909.1].
912	Close Graded Asphalt Concrete Surface Course	Mixture designation [912.1].
937	Stone Mastic Asphalt (SMA) Binder Course and Regulating Course	Mixture designation [937.1]. Resistance to permanent deformation classification [937.5, Table NG 9/25 and PD 6691 Table D7]. Whether resistance to permanent deformation is to be monitored in the permanent works [937.6].

943 AR	Hot Rolled Asphalt Surface Course and Binder Course (Performance-Related Design Mixtures)	Thickness if not in accordance with Clause 943.2 [943.2]. Resistance to permanent deformation classification [943.6 Table NG 9/32 and PD 6691 Table C3]. Whether resistance to permanent deformation is to be monitored in the permanent works [943.10].
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## HMEP CL 921SR SURFACE MACROTEXTURE OF BITUMINOUS SURFACE COURSES

1. Where specified in Appendix 7/1, the initial surface macrotexture for bituminous surface courses shall be measured using the volumetric patch method described in BS EN 13036-1 and the procedures in BS 594987, clause 8.2. The sand patch method in BS 598-105 (now withdrawn) may be used for routine monitoring, but the BS EN 13036-1 method shall be used as the reference method in case of dispute.
2. Texture depth shall be measured by 10 individual measurements taken at approximately 5m spacing along a diagonal line across the lane width. Unless otherwise specified in Appendix 7/1, at least one set of 10 measurements shall be made for each 250m section of carriageway lane. The average texture depth for each set of 10 individual measurements and the average texture depth of each 1,000m section (or complete carriageway lane where this is less than 1,000m) shall not be less than the appropriate values shown in Table 9/3, unless otherwise specified in Appendix 7/1.
3. The requirements for initial texture depth shall comply with Table 9/3 of Annex B of IAN 154/12, but with the following additional notes:
  - i) The length for each section may be either 1,000m or the scheme length (if shorter than 1,000m).
  - ii) High stone content HRA such as 55/10 HRA and 55/14 HRA shall be classified within the same category as hot applied thin surface course system to Clause 942 with upper (D) aggregate sizes of 10mm and 14mm respectively.

Annex B: Clause 921 Table 9/3 Table 9/3SR Requirements for Initial Texture Depth				
Road Type	Surfacing Type	Average per 1,000 section, mm		Average for a set of 10 measurements, mm (minimum)
		Minimum	Maximum	
<b>High speed roads</b> Posted speed limit $\geq$ 50 miles/hr (80 km/hr)	Hot applied thin surface course systems to Clause 942 with an upper (D) aggregate size of 14mm	1.3	1.8	1.0
	Hot applied thin surface course system to Clause 942 with an upper (D) aggregate size of 10mm	1.1	1.6	0.9
	Hot applied thin surface course systems to Clause 942 with an upper (D) aggregate size of 6mm	1.0	1.5	0.9
	Cold applied ultra thin surface course system to Clause 942	1.5	2.0	1.2
	Chipped hot rolled asphalt, surface dressing and all other surfacing	1.5	2.0	1.2
<b>Lower speed roads</b> Posted speed limit $\leq$ 40 miles/hr (65 km/hr)	Thin surface course systems to Clause 942 with an upper (D) aggregate size of 14mm or less	1.0	1.5	0.9
	Chipped hot rolled asphalt, surface dressing and all other surfacing	1.2	1.7	1.0
<b>Roundabouts on high speed roads</b> Posted speed limit $\geq$ 50 miles/hr (80 km/hr)	Hot applied thin surface course systems to Clause 942 with an upper (D) aggregate size of 10mm	1.1	1.6	0.9
	Chipped hot rolled asphalt, surface dressing and all other surfacing	1.2	1.7	1.0

Annex B: Clause 921 Table 9/3 Table 9/3SR Requirements for Initial Texture Depth: continued				
Road Type	Surfacing Type	Average per 1,000 section, mm		Average for a set of 10 measurements, mm (minimum)
		Minimum	Maximum	
Roundabouts on lower speed roads Posted speed limit $\leq$ 40 miles/hr (65 km/hr)	Hot applied thin surface course systems to Clause 942 with an Upper (D) aggregate size of 10mm	1.1	1.6	0.9
	Hot applied thin surface course systems to Clause 942 with an upper (D) aggregate size of 6mm	1.0	1.5	0.9
	Chipped hot rolled asphalt, surface dressing and all other surfacing materials	1.0	1.5	0.9

## HMEP CL 943AR HOT ROLLED ASPHALT SURFACE COURSE AND BINDER COURSE (PERFORMANCE-RELATED DESIGN MIXTURES)

1. Performance related design Hot Rolled asphalt surface and binder courses shall conform to BS EN 13108-4, the detailed requirements from BSI PD 6691 Annex C section C.2.5.1.3, the requirements of this Clause and those specified in Appendix 7/1.

### Layer Thickness

2. The nominal thickness of the hot rolled asphalt surface course layer shall be either 45 mm or 50 mm unless otherwise specified in Appendix 7/1.

### Binder and Binder Modification

3. Bitumen processed during refining to provide a binder with enhanced properties without the addition of a modifier, shall have a British Board of Agrément HAPAS Roads and Bridges Certificate.
4. For binders without BBA HAPAS certification, the Contractor shall provide data sheets giving details of the properties of modified binders, whether the modifier is pre-blended with bitumen, the bitumen is modified during refinery processing or modified by addition into the asphalt mixer, including those specified in Appendix 7/1. These shall include rheological data in accordance with Clause 956 and cohesion in accordance with Clause 957. Without BBA HAPAS certification, polymer modified binders, modified binders or additives shall not be used without the approval of the Overseeing Organisation.

**Coarse Aggregate**

5. Coarse aggregate shall be crushed rock or slag complying with BS EN 13043 and Clause 901. The resistance to polishing of the coarse aggregate for surface course shall comply with category PSV44 in accordance with BS EN 13043, clause 4.2.3.

**Deformation Resistance**

6. The resistance to permanent deformation of the mixture shall be in accordance with the appropriate class selected from Table C.3 of BSI PD 6691, as specified in Appendix 7/1.

**Coated Chippings for Surface Course**

7. When required, coated chippings shall be 14/20 mm or 8/14 mm size as specified in Appendix 7/1 and comply with Clause 915.

**Surface Macrotexture for Surface Course**

8. The surface macrotexture shall comply with Clause 921.
9. Compaction Control Procedures
10. Control testing for compaction and resistance to permanent deformation shall be carried out in accordance with BS 594987 section 9.5.2.
11. When specified in Appendix 7/1, the resistance to permanent deformation of material laid in the permanent works shall be monitored by testing in accordance with clause F.3 of BS 594987 Annex F. Six cores shall be taken from the first kilometre length of material from each mixing plant and thereafter one further core from each subsequent lane kilometre. Results shall be assessed on successive rolling means of sets of six consecutive results and shall be deemed to conform if the mean is no greater than the specified value and individual values not more than 50% greater than the specified value.

**Trafficking Newly Laid Surfacing**

12. The Contractor shall ensure the pavement material has adequately cooled and hardened before the road is opened to traffic. Unless otherwise agreed by the Overseeing Organisation, the road shall not be opened to traffic if its surface temperature exceeds 25°C unless the maximum temperature within the mat has fallen below 35°C.

## NG 943AR HOT ROLLED ASPHALT SURFACE COURSE AND BINDER COURSE (PERFORMANCE-RELATED DESIGN MIXTURES)

1. This clause is for the specification of hot rolled asphalt mixtures that have been designed to achieve controlled levels of resistance to permanent deformation (rutting) measured by the wheel tracking test. These mixtures are used as both surface course and binder course. They are particularly suitable as a regulating binder course under thin surfacing and as a binder course over bridge deck waterproofing. When used as surface course they must be chipped to provide a skid resistant surface. The preferred material type should be HRA 35/14F however HRA 30/14F or HRA 55/14F may be used subject to meeting the performance requirement and an approval from the Overseeing Organisation. An example of Appendix 7/1 requirements is given on Table NG 943AR/1.

**Table NG 943AR/1 Requirements for Construction Materials (Example)**

943 AR	Hot Rolled Asphalt Surface Course and Binder Course (Performance-Related Design Mixtures)	Thickness if not in accordance with Clause 943.2 [943.2]. Resistance to permanent deformation classification [943.6 Table NG 9/32 and PD 6691 Table C3]. Whether resistance to permanent deformation is to be monitored in the permanent works [943.10]. Coated chippings size, when required [910.3]. Required declared PSV category for chippings [915.2]. Required maximum AAV category for chippings [915.2]. Whether surface macrotexture measurement is required [921.1]. Interval and frequency of macrotexture measurements, if not 10 per 250m [921.2]. Initial texture depth, if not in accordance with Table 9/3 [921AR].
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2. Using hot rolled asphalt surface course to this clause will ensure a good level of resistance to permanent deformation within the surface course itself. Designers should be aware that significant rutting often occurs in the lower layers of the pavement and use of a performance designed surface course on an inadequate substrate will not protect against this. To provide adequate resistance to deformation, binder course and base designed in accordance with Clauses 929, 930 or 937 should be used, particularly in the top 100 mm of the pavement.

3. In almost all cases, the use of a modified binder or binder modifier will be required in order to achieve the more onerous (Class 2) performance level. Since these are generally proprietary products, sub- Clause 5 requires the submission of information

to the Overseeing Organisation for approval. If there is evidence of successful use of a modified binder/ modifier in similar conditions, the presumption should be of approval.

4. Verification of wheel tracking properties for each mixture will be provided in the form of a Type Test Report in accordance with BS EN 13108-20. This verification will have been carried out in accordance with a protocol given in BS 594987 Annex F. This protocol is based on the job mixture approval trial procedure specified previously in earlier editions of Clause 943, is technically equivalent and provides the same information. Requirements appropriate to traffic and stress condition should be selected from Table NG 9/33 and included in Appendix 7/1.
5. On particularly large or critical projects it may be appropriate to monitor resistance to permanent deformation in the permanent works. If required, this should be clearly indicated in Schedule 5 of Appendix 7/1 along with the site classification.
6. When specifying resistance to permanent deformation, it will be necessary to take into account the transitional problems brought about by the change in the wheel tracking test method from BS 598 Part 110 to BS EN 12697-22, which uses similar equipment but different duration and loading. Further information is given in the note to BSI PD6691 Table B4. Work is in hand to establish criteria for the new method, but in the interim, requirements should be based on the BS 598 test but with data provided to show the values for the same mix tested to the BS EN 12697 method.

TABLE NG 9/33: Classification of Sites by Traffic and Stress Condition for Resistance to Permanent Deformation of Performance Related - HRA Surface Course and Binder Course to Clause 943						
	Site Category	Site Definition	Traffic at Design life (Commercial vehicles per lane per day)			
			CLASS 1			CLASS 2
			Up to 250	251 - 500	501 - 1000	1001 - 1500
I & II	A	Motorway (main line)	BSI PD6691 Table C.3, Classification 1 (45°C)			
	B	Dual carriageway (all purpose) non-event sections				
	C	Dual carriageway (all purpose) minor junctions				
	D	Single carriageway non-event sections				
	E	Single carriageway minor junctions				
IA & IIA	As I and II, above, but with contraflow anticipated during summer months		BSI PD6691 Table C.3 Classification 2 (60°C)			
III	F	Approaches to and across major junctions (all limbs)				
	G1	Gradient 3% to 10%, longer than 50 m				
	L	Roundabout				
IIIA	As III, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill					
IV	G2	Gradient steeper than 10%, longer than 50 m				
IVA	As IV, above, but with contraflow anticipated during summer months or in a south-facing cutting uphill					
V	J/K	Approach to roundabout, traffic signals, pedestrian crossing, railway level crossings and similar				

## HMEP CL 946SR PATCHING AND REPAIRS TO POTHoles AND DEPRESSIONS (INCLUDING EMERGENCY PATCHING)

### General

1. Patching is defined as replacement of surface course, binder course and base where the materials are laid in small areas.
2. The existing defective surfacing and/or temporary filling of trenches and depressions shall be broken out so as to provide a cavity with straight vertical edges. The edges of patch repairs are to be cut back to sound, full thickness material and are to be clean and dry prior to application of any sealing compound on the vertical faces of joints.
3. Joint edges shall be formed as specified in sub-Clause 903.22.
4. All loose material shall be removed off site.
5. Replacement materials shall be as specified in Appendix 7/1.
6. Bond coat shall be applied in accordance with Clause 920.
7. All construction layers shall be laid and compacted such that on completion each layer shall be at the same level as the adjacent course.
8. Alternatively patching may be carried out using proprietary in-situ recycling repair systems incorporating indirect infra red heating having an appropriate British Board of Agrément HAPAS Roads and Bridges Certificate

### Emergency Patching

#### General

9. Emergency patching shall be carried out with approved kits of proprietary Emergency Patching Materials (EPM) complying with this clause.

#### Surface preparation and usage

10. The surface of the road shall be brushed mechanically or by hand with a stiff broom to remove loose material. Any standing water shall be brushed away, but the surface may remain damp.
11. Installation shall not be undertaken unless weather conditions are such that the repair material will have at least 30 minutes in which to cure and harden.

#### Components of the Emergency Patching Material Kit

12. Each kit shall comprise the materials and tools necessary to carry out an emergency repair to the surface of a road.
13. Each kit shall contain all the constituents which, when mixed together, will satisfy the performance requirements set out in this clause. It shall contain sufficient coarse

aggregate with a minimum PSV of 55, for application to the laid material to ensure that a durable, skid resistant surface can be produced.

14. Each kit shall contain full and detailed instructions, including if necessary a cd/dvd video or a series of still photographs, to ensure that inexperienced operatives can prepare and lay the emergency patching material correctly without difficulty.
15. No individual part of a kit shall weigh more than 20 kg.

#### **Performance Requirements for the Patching Material**

16. The repair material shall have the following characteristics:
  - (i) It shall be capable of being mixed and spread by hand in thickness from 3 mm to 30mm.
  - (ii) It shall cure to a strength such that it is capable of being trafficked by heavy vehicles without damage within 30 minutes of installation when laid at surface temperatures between 3°C and 40°C.
  - (iii) None of the material shall debond or delaminate from the existing surface of the road for a period of at least 7 days from installation. Any subsequent delaminated material shall not be of sufficient size as to cause a hazard to traffic.
  - (iv) It shall retain surface applied aggregate.
  - (v) It shall have a minimum shelf life of 12 months.
17. The performance shall be demonstrated at a site installation trial and by laboratory evaluation.
18. Products shall be independently certified to show compliance with this Clause.

#### **Repairs to Potholes and Depressions**

19. Temporary repairs to small areas of surface courses including holes for road stud sockets shall be carried out in accordance with Appendix 7/22. Alternatively patching may be carried out using proprietary in-situ repair systems incorporating indirect infra red heating having an appropriate British Board of Agrément HAPAS Roads and Bridges Certificate.
20. Temporary filling to depressions shall be carried out using a proprietary material specifically formulated to treat such depressions, all in accordance with sub-Clause 2 to sub-Clause 18 of this clause.
21. Permanent filling to depressions shall be carried out using hot mix material or proprietary in-situ recycling systems complying with Series 900, having an appropriate British Board of Agrément HAPAS Roads and Bridges Certificate, CE Marking or a certificate issued by other recognised and independent technical approval body.

22. All repairs shall ensure the presence of an impermeable seal with any joint and/or interface with the surrounding material to prevent moisture ingress.
23. Temporary and permanent repairs are expected to last longer than 12 months and 5 years respectively. Applied repair materials shall be guaranteed to be in serviceable condition for at least 9 months and 3 years for temporary and permanent repairs respectively.

### NG 946SR PATCHING AND REPAIRS TO POTHOLES AND DEPRESSIONS (INCLUDING EMERGENCY PATCHING)

1. Repairs should not be completed in adverse weather condition unless there is a specific instruction from the Overseeing Organisation that the Work must be done to prevent greater risk to the road users. In the latter case, the Contractor may wish to renegotiate the extent of performance guarantee with the Overseeing Organisation.
2. For temporary repairs, proprietary cold applied treatments can be used provided they have an appropriate HAPAS or Roads & Bridges Certificate applicable to the traffic category or have demonstrated performance over a 2 year Type Approval Installation Trial (TAIT).
3. For permanent repair, thicker layers may provide better durability and longer service life than thinner layers. This should be done by deeper planing into the substrate and the finished level should tie in with the surrounding surfacing.
4. An example of requirements for construction materials in Appendix 7/1 is given on Table NG 946AR/1.

**Table NG 946AR/1 Appendix 7/1 Requirements for Repair and Patching Materials (Heading Example)**

Type of repair material [946.5]:
Specified bond coat [946.6]:
Required declared PSV category [946.13]:
Required declared performance [946.16]:
Required declared laboratory testing [946.19-23]:
Surface integrity performance guarantee [946.28]:

## HMEP CL 970 AR COLOURED SURFACING FOR LANE DEMARCATION

1. The Contractor shall be responsible for the selection/design of the surface treatment to provide a coloured surface satisfying the criteria, the performance standards and warranty specified in the following sections of this Clause.
2. Preliminary site investigation shall be carried out by the Contractor and this shall at least include visual condition survey to establish a reference with respect to existing surface condition and any pre-existing defect which may be considered influential to the performance of the new coloured surfacing. Findings from this investigation shall be submitted to the Overseeing Organisation for approval.
3. Prior to application of coloured surface treatment, any existing surface treatment shall be removed by grinding or other method approved by the Overseeing Organisation before application. The same applies to any existing defect recorded during the site investigation.
4. The Contractor shall guarantee all workmanship and materials for a period of two years from the date of completion or the date of opening to traffic, whichever is the later, against colour change, defects and failure to meet the specified performance standards. The approved design and preliminary site investigation reports as described in sub-Clauses 1 and 2 shall be used for referencing purposes with performance criteria as specified in sub-Clause 12.
5. The material shall be machine laid, unless otherwise authorised by the Overseeing Organisation for small areas as specified in Appendix 7/2.
6. The material shall be either bitumen emulsion based or a synthetic resin based system. The colour required will be stated in the appropriate Works Instruction and selected from the following:
  - a. Natural- grey or buff;
  - b. Red- Signal Red BS 381C ref 537;
  - c. Green- Deep Chrome Green BS 381C ref 267;
  - d. Others- To be specified and agreed with the Overseeing Organisation.
7. Areas to receive coloured surface treatment are shown on the contract drawings but are typically bus lanes, cycle advance stop reservoirs, cycle lanes, cycle tracks, toucan crossings and pedestrian crossings. Finished colour of these areas shall be proposed to Overseeing Organisation for approval not less than 14 calendar days prior to work commencing on site.
8. Selected colour shall not compromise the clarity of road markings. Road markings to be applied at locations specified in the contract drawings and shall comply with Clause 1212 of this Specification.

9. The minimum surface texture depth, when measured in accordance with the method in BS EN 13036-1, shall be 1.5mm. The PSV and AAV of the aggregate shall be stated in the Works Instruction.
10. All joints shall be formed such that there shall be no ridges or bare strips. Joints shall generally be parallel or perpendicular to the centre line of the carriageway. Kerbs, edges and other areas not to be treated shall be suitably masked with self-adhesive masking material.
11. The finished surface shall have a uniform texture and appearance without variation due to segregation or variations in the mixture. The surface shall be free from blow holes and surface irregularities in excess of 3mm beneath a 1 metre straight edge. The finished surface shall also be free from badly aligned joints, excess overlapping, droppings or damage by rain or frost.
12. The performance throughout the guarantee period will be assessed against the following criteria:
  - a. The extent of loss of material from the substrate will be visually monitored and failure will be deemed to have occurred when the substrate is visible in individual areas greater than 0.1m<sup>2</sup> or the total area of loss of material is greater than 0.2% of the area treated.
  - b. Surface texture retention as described in sub-Clause 9.
  - c. Where red or green colouring is specified, then this should be retained.

Any area failing to meet the required performance standards at any time during the guarantee period shall be subject to remedial action by the Contractor.

13. Overspraying of failed material will not be permitted.

## NG 970 AR COLOURED SURFACING FOR LANE DEMARCATION

1. An example of Appendix 7/1 requirements is given on Table NG 959AR/1.

<p><b>Table NG 970 AR/1 Appendix 7/1 Requirements for Coloured Surfacing (Heading Example)</b></p>
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<p>Type Classification e.g. binder type [970 AR.6]:</p>
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<p>Required declared PSV category [970 AR.9]:</p>
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<p>Required minimum texture depth category [970 AR.9]:</p>
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<p>Required maximum AAV category [970 AR.9]:</p>
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<p>Required finished colour [970 AR.6]:</p>
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2. It is recommended that bus lanes, cycle lanes and cycle advance stop reserves shall use aggregate with PSV not less than 55. All approaches to toucan crossings and pedestrian crossings shall use aggregate with PSV not less than 68.

## HMEP CL 971 AR STRESS ABSORBING MEMBRANE INTERLAYER (SAMI)

1. The Product shall be installed in accordance with the manufacturer's instructions unless otherwise instructed by the Overseeing Organisation. It shall have a British Board of Agrément HAPAS Roads and Bridges Certificate, CE Marking or a certificate issued by other recognised independent technical approval body. In the event that no such certificates have been issued, the product shall have the approval of the Overseeing Organisation.

## NG 971 AR STRESS ABSORBING MEMBRANE INTERLAYER (SAMI)

The following guidance notes have been produced by ADEPT for the use of Stress Absorbing Membranes, and considers the use of paving fabrics and grids to enhance the durability of an asphalt overlay in a cracked pavement. The products used are generically called Geosynthetics in this document and the installed system is known

as a Stress Absorbing Membrane Interlayer [SAMI]. It can include a range of products as described below

In a draft IAN the Highways Agency indicated that these materials cannot be used to justify a reduction in depth in a designed pavement. However, they can provide considerable benefits in maintenance by prolonging the life of the pavement and hence substantially reducing the ongoing drain on the maintenance budget of sub-standard or non-engineered roads.

It has been the experience of a number of ADEPT members that the careful use of reinforcing fabrics provided an increase in the life of these overlays and hence reduction in the long term drain on resources such that, despite great restrictions in budget and increasing volumes of traffic, a stabilisation of the overall deteriorating condition of the roads in the area was achieved, and indeed, on occasion turned to an overall improving condition.

#### **Potential benefits of introducing a SAMI**

The potential benefits of introducing a SAMI include:

1. Reduction of propagation of reflective cracking;
2. Ensuring sound and uniform bond between the bituminous layers;
3. Sealing, thereby preventing water and air travelling down through and degrading the pavement and foundation layers;
4. Provision of tensile strength to reduce cracking and splitting of the pavement as a result of deformation under traffic over poor ground.
5. Reducing the tendency of excessive bitumen in old layers to migrate upwards and contaminate overlays.

Realisation of the benefits requires careful selection of the appropriate product type for any particular situation, followed by good quality control on site to ensure that the proper preparation and laying procedure is followed. A number of product suppliers actually provide and may insist on specialist teams to lay the material, thereby ensuring the availability of the necessary expertise and appropriate laying equipment.

It would be of particular advantage if it were possible to quantify the benefits listed above. However despite extensive and lengthy research this remains a difficult area. This is mainly because the quality of and movement in the existing pavement below the SAMI is so very variable and together with the thickness of and type of overlay has a significant effect on the time before surface maintenance is again necessary.

Asphalt surfacing materials that are fatigue and/or crack resistant will provide longer lives than stiff or brittle materials when used with a SAMI. The bitumen type and quantity in the asphalt overlay is the key determinant of this. Crack resistant Thin Surface Course Systems and Hot Rolled Asphalt Surface Course, and SMA and HRA binder courses are particularly suitable. The requirement for flexibility may

conflict with the requirements for stiffness and rut resistance and this may have to be accommodated by the use of appropriate polymer modified binder and/or suitable mix design.

In considering whether to incorporate a SAMI/reinforcing layer, it is sometimes useful to calculate the thickness of overlay which could be provided for the same cost, and then consider which will give the greater benefit, the SAMI or the extra overlay. It may be appropriate to carry out this exercise for a number of different product types.

**Types of Geosynthetics available**

1. Grids, made from steel wire, polypropylene, or other synthetic material.
2. Woven fabrics
3. Non-woven or continuous monofilament needle punched fabric.
4. Synthetic grid bonded to a non-woven fabric
5. Sprayed rubber membrane with microasphalt protection layer.

Fixing methods vary; steel and some synthetic grids are fixed down by nailing or stapling to the surface, other synthetic grids are bonded to a self adhesive fabric, and fabrics may be self adhesive or laid in a bituminous bond coat.

The potential benefits for the various materials are summarised in Table 1

SAMI System	Reduced reflective cracking	Enhanced bond between layers	Sealing	Tensile strength
Steel grids	Yes	No	No	Yes
Synthetic grids	Yes	No	No	Yes
Woven fabrics	Yes	No	No	Some
Non-woven fabrics	Yes	Yes*	Yes*	Little
Synthetic grid + non-woven fabric	Yes	Yes*	Yes*	Yes
Sprayed membrane	Yes	Yes	Yes	No

\* When laid in a fully impregnating bond coat. With self-adhesive materials, these benefits would be much less.

**Suitable sites for the introduction of a SAMI / asphalt reinforcement**

The circumstances where these materials provide most benefit include:

1. Over cracked or heavily reinstated surfaces where simple overlay tends to be vulnerable to reflective cracking. All cracking other than hairline cracking is detrimental to the structural condition of the pavement. It reduces the strength and lets in water. The water can freeze leading to more damage, fragmentation and delamination, and ultimately to complete failure. In more severe cases where the cracking extends through the full depth of the bound layers, water ingress can lead to softening of the foundation and even to mud pumping whereby fine material is pumped up to the surface.
2. Roads over poor or uneven foundation where settlement and subsequent cracking is a problem. It is accepted that a reinforcing layer in itself does little to reduce settlement, but over poor ground it can greatly reduce cracking and subsequent failure, particularly if combined with a suitably flexible surfacing material. Composite systems and sprayed systems have a waterproofing function that can help improve foundation strength by reducing moisture ingress
3. Over the joint where a carriageway is being widened or extended, and thereby vulnerable to future cracking, a strip preferably at least 500 mm each side of the joint.
4. Over joints and cracks in older concrete carriageways where simple overlay tends to be vulnerable to reflective cracking. Where there is greater movement a double layer of reinforced fabric at least 500 mm wide with bond coat can be used over the joint.
5. On steep gradients or tight radii subject to heavy commercial traffic where inter-layer stresses are high and enhanced bond is beneficial; provided that adequate thickness of overlay is provided.

#### **Recommended thickness of overlays**

1. The thicker the overlay, the longer the time before reflective cracking becomes evident. This is because structural movement in the base is reduced by load spreading and thermal movement is reduced by the resulting thickness. If an overlay thickness greater than 160mm is being provided, a SAMI will not normally be justified against reflective cracking, but it may provide a reinforcing benefit over poor ground.
2. The depth of overlay will be as designed for the structural requirements or the restraints imposed by the particular site, but as a minimum must be compatible with the reinforcing material used. It is generally preferable to place the material as low as possible in the resurfacing layers, though a regulating layer may be needed first. ( See below)
3. It is not possible to lay a regulating scratch course (which tapers out to nothing in places) over the reinforcing material as it would then be vulnerable to damage by the paver. It must be overlaid by a full width layer. The minimum overlay is typically 40mm over a woven or unwoven fabric or spray system, 50mm over a

reinforced fabric, 60mm over a synthetic grid, and at least 70mm in two courses over a steel grid, preferably more.

#### **Preparation and laying procedure for grids and fabrics.**

1. To obtain satisfactory results, proper preparation is necessary as is suitable weather. Such circumstances are generally not compatible with winter work or rushed work at the end of the financial year.
2. The reinforcing material to be used must be carefully chosen, consideration being given to the strength and condition of the pavement, and the particular problems to be addressed. Consider also the laying circumstances; will a full carriageway possession be available, or only a partial one with traffic being accommodated past the works. This will clearly affect the choice of width of material utilised.
3. The surface to be overlaid must be clean, adequately level, and adequately dry (see 5 below).
  - a. Whether a grid or a fabric is being used, it must be in close contact with the surface. Excessive undulation prevents this, and it is necessary to regulate the surface first.
  - b. If the texture of the surface is too open or uneven, for example, very open textured, heavily weathered or fretted bitumen macadam or heavily pitted HRA; it may accept a plain grid stapled down, but adequate strength of fixing can be difficult to achieve; a woven fabric will not achieve adequate contact to bond properly; non-woven fabrics and sprayed systems can adapt to greater unevenness but still have their limits.

In these cases, levelling with fine bituminous material is necessary, e.g. asphalt concrete 6 dense, HRA 0/2, or HRA 50/10

4. It is also appropriate at this stage to carry out any patching and to reconstruct any particularly soft areas, taking into account that no system can accommodate more than very minor differential vertical movement across a joint or crack.
5. Where a bond coat is needed, straight run bitumen is quickest and most effective, but it requires the surface and the weather to be absolutely dry. It also gives rise to some safety concerns, but with it, the fabric and the overlay can follow immediately on the binder. The alternative is bitumen emulsion which can tolerate a small amount of humidity and ground dampness (not wet), but it must be allowed to break before the fabric is laid, and hence at the very times when only it can be used because of the weather, it creates a delay of up to 30 or 40 minutes. Cut-back bitumen should not be used as the volatile oils cannot dissipate adequately through the overlay.

6. The rate of spread of bond coat must also be carefully considered. With fabrics, whether woven or unwoven, whether backed by a grid or not, full penetration is required, otherwise bond will be compromised. With unwoven fabric, the starting point would normally be about 1.1 l/sq m of residual binder (or otherwise depending on the manufacturer's instructions), but this will be adjusted down on a very fat surface, and increased over an open surface which would tend to absorb the binder. Full penetration is not necessary when the fabric is first laid as the hot overlay will tend to draw the binder up thereby achieving full penetration at that stage (full penetration when fabric is laid would lead to great difficulty in the overlaying operation). If in doubt, the rate of spread to achieve full penetration can easily be tested.
7. The material must be laid flat and any wrinkling or rucking avoided. It will be possible to pull some materials round slight bends, but at sharper corners it is necessary to cut and lap it, with extra bond coat if appropriate. If wrinkling or rucking occurs, it must be dealt with by cutting and lapping the surplus material, with a further layer over the joint if needed to provide the appropriate lap, and all layers properly stuck down.
8. The specified overlaps must be achieved at all transverse and longitudinal joints, normally 150mm for fabrics and up to 300mm with grids. With steel grids, the lapped joints must be wired together to avoid movement and separation, whether during tensioning or later when in service. Note: Shovels-full of 'fluxed macadam or 'bitmac' do not provide the necessary strength!
9. Grids are pretensioned by stretching before fixing down whereas the fabrics are merely laid taught, achieved by a simple braking mechanism on the laying rig. When laying self adhesive fabric or in a bond coat, it is necessary to have brushes or a roller fitted to the rig to ensure full and immediate bedding and hence adhesion of the material.
10. The reinforcing material will be trafficked by the laying rig, by the overlay paver, and by the delivery lorries. Care must be taken to avoid damage to the material by these or any other vehicles, whether by harsh braking, turning, or even by the force generated by the spreader pushing the delivery lorry. The stapled down materials and some composite fabric/grid systems are particularly vulnerable to damage by moving and rucking at this time, and it is sometimes necessary to lay asphalt ahead by shovel to protect the material from the wheels of the paver.
11. Details of the information to be supplied by the installer prior to and during installation, and the installed performance tests are given in Appendix A **Note; this guidance is of general application. In using any particular material, the manufacturer/suppliers instructions must be followed.**

**Appendix A****Information to be supplied prior to installation**

The geosynthetic products used shall have CE Marking to BS EN 15381:2008 *Geotextiles Characteristics for Use in Pavements and Asphalt Overlays*.

Product information shall give details for suitable asphalt overlay materials, minimum air/surface temperatures, permitted maximum temperatures, the minimum overlay thickness so that no defects are introduced in the surface

A detailed method statement shall be supplied giving the following information and such other site specific information the installer believes necessary

Risk assessments and Health and Safety informationStaff Competency

Details of training and competency of supervisors and operatives. E.g CSCS Cards and NVQ.

Traffic Management details

All traffic management shall comply with Chapter 8 installed by operatives operating to NHSS 12D

Surface Preparation

The acceptance parameters of the surface on which the product is to be laid with respect to roughness, dryness and methods for cleaning and if necessary drying

Resealing existing joint or cracks and time before SAMI can be applied

Treatment of ironwork

Installation ( as appropriate )

The installer shall inspect the site prior to installation and confirm that it is suitable for the application of the system and that the material type and thickness of overlay is appropriate for the product.

Any special instructions necessary for the site team

**Bond coat**

Details of calibration certificates for bond coat spray device

Bond coat details by reference as appropriate to the parameters given in

EN 12591, *Bitumen and bituminous binders — Specifications for paving*

*grade bitumens*

EN 13808:2005, *Bitumen and bituminous binders — Framework for specifying cationic bituminous emulsions or*

EN 14023, *Bitumen and bituminous binders — Framework specification for polymer modified bitumens.*

Binder shall be CE marked

Method for determining rate of spread of bond coat to take account of surface porosity

Treatment of edges and laps.

### **Geosynthetic**

Method of laying including details of joints laps, coping with radii and ensuring intimate contact with road surface.

Methods of tensioning

Methods of firmly attaching to the road surface

Details of any protection or additional over-layer added above the geosynthetic to complete the SAMI System including test required for control of the material and rate of spread

### **Details of control tests to be carried out during installation.**

These shall at least include measurement of rate of spread of bond coat [by carpet tile test], measurement of additional over-layer (by for example computer records).

### **Tests to be carried out after installation**

Where the overlay thickness is up to 160mm at least two cores shall be taken per 500 sq.m from the finished surface or after the first layer of asphalt has been overlaid as dictated by the site programme. The coring shall be done carefully and ensure at least 50mm of the existing road pavement is included below the SAMI

The cores shall be tested in a UKAS accredited laboratory for shear bond using the torque bond test as described in the Guideline for Thin Surfacing and Tensile Adhesion Test as described in TRL 176

Tests results shall be provided in a timely manner

The values required depend upon the thickness of asphalt overlay and are as follows (Based upon IAN 96 Rev 1 *Guidance on implementing results of research on bridge deck waterproofing*)

Surfacing thickness	>120 mm <sup>[1]</sup>	120 – 90 mm <sup>[1]</sup>	90 – 60 mm	< 60mm
Tensile adhesion test <sup>[2]</sup>	0.30MPa	0.50MPa	0.70MPa	0.8 MPa
Shear bond test <sup>[2]</sup>	0.30MPa	0.30MPa	0.40MPa	0.6 MPa

Note 1. Where work is soundly executed, the higher values of bond should be readily achieved, and must be seen as beneficial regardless of the overlay thickness.

Note 2. Where significant braking or turning forces are expected or the SAMI used as part of a structural layer over a soft substrate, the values for 90-60mm surfacing thickness should be achieved

Note 3. Mean of 3 cores

Note 4. Well compacted asphalt layers and the bond between them will withstand these forces without destruction if properly laid and fully compacted. Should failure occur in or between the asphalt layers at values below these quoted, the asphalt installation is defective and may need replacement. It may be prudent to take additional cores in a case of doubt to enable the SAMI bond to be assessed.

## HMEP CL 972 AR STONE MASTIC ASPHALT SURFACE COURSE

### General

1. Stone Mastic Asphalt surface course shall comply with the requirements of BS EN 13108 Bituminous mixtures - Material specifications Part 5, PD 6691 Guidance on the use of BS EN 13108. Stone Mastic Asphalt shall be designed and manufactured to comply with the requirements of PD 6691 annex D unless otherwise varied by this clause or Appendix 7/1 and shall be transported handled and laid in accordance with the requirements of BS 594987.

### Materials

#### Aggregate

2. The coarse aggregate shall be material substantially retained on a 2mm test sieve, conforming to all appropriate requirements of BS EN 13043:2002 and consisting of either crushed rock or crushed gravel of one or more of the following groups: basalt, gabbro, granite, gritstone, hornfels, porphyry or quartzite. The use of secondary, processed aggregate such as steel slag may be allowed subject to approval from the Overseeing Organisation.
3. Unless otherwise specified in Appendix 7/1, the coarse aggregate shall have the following properties:

- The flakiness index for the coarse aggregates shall be  $FI_{20}$ ;
  - Resistance to Fragmentation – Category  $LA_{30}$ ;
  - Aggregate abrasion Value – for carriageway material, not more than 12, after reference to HD36/06 Table 3.2;
  - Durability (Water Absorption) – Category  $WA_{24} 2$ ;
  - Polished Stone Value – the minimum PSV to be specified in Appendix 7/1 for carriageway surface course after reference to Table NG 971AR/1.
  - The fines content category for the coarse aggregate shall be  $f_4$ ;
  - The resistance to surface abrasion for the coarse aggregate shall be  $AAV_{12}$ .
4. The fine aggregate shall substantially pass a 2mm test sieve and be a crushed material from either crushed rock or crushed gravel of one or more of the following groups: basalt, gabbro, granite, gritstone, hornfels, porphyry or quartzite.
5. In Clause 971.13 there is a requirement to provide alternate testing methods A and B in Appendix 1/6. This should be provided by the Overseeing Organisation.

#### Filler

6. Added filler shall be crushed limestone or other approved material in accordance with the requirements of BS EN 13043, 5.2.1.
7. Hydrated lime may be added up to a maximum of 2% by mass of the aggregate

#### Binder Grades

8. The binder shall be polymer modified conforming to BS EN 14023:2010. The Overseeing Organisation's approval to use alternative materials needs to be sought on a scheme by scheme basis and should not be assumed.

#### Mixture Design

9. The target grading for the mixture shall fall within the limits given in PD 6691 Table D1 for 0/6, 0/10 and 0/14mm nominal aggregate sizes (SMA 6, SMA 10 and SMA 14 respectively), unless agreed otherwise by the Overseeing Organisation. The manufacturer shall carry out initial type testing in accordance with BS EN 13108 – 20 to demonstrate conformity with BS EN 13108 – 5 and PD 6691, as amended below.
10. Minimum target binder contents (by mass of the total mixture) for each nominal aggregate size shall be:

SMA 14:  $B_{min} 6.3$

SMA 10:  $B_{min} 6.7$

SMA 6:  $B_{min} 7.1$

The above values assumed the use of natural coarse aggregates. If secondary processed aggregate such as steel slag is used, the minimum target binder content shall be adjusted to account for the much higher particle density of this aggregate.

11. The SMA mixtures shall include a minimum fibre content of 0.3% (by mass of the total mixture). The average binder drainage category of a set of specimens tested in accordance with BS EN 12697-18:2004 (Clause 5) Schellenberg method shall be less than 0.3%.
12. The void content of laboratory compacted specimens of the mixture at target composition prepared and tested as detailed in BS EN 13108-20:2006 (Annex C, Table C.1) shall fall within 3 to 4%. When tested in accordance with PD 6691 Table 4 but with the amendment that BS EN 12697-6 procedure C, sealed specimen shall be used to determine specimen bulk density.
13. The resistance to permanent deformation of samples at target composition taken in accordance with BS 594987:2007, Annex G, shall be determined in accordance with BS EN12697-22:2003 using the small device and Procedure B in air at a test temperature of 60 °C. The results shall be recorded in the Producer's quality management system and reported as part of the TAIT procedures.

### Compaction

14. The degree of compaction shall be assessed in accordance with Clause 903 AR and the insitu air voids shall comply with Table 903 AR/1.
15. The laid thickness shall be within the range permitted in Table 972AR/1.

Table 972 AR/1 Permitted laid thickness		
Mixture description	Thickness range (mm)	Minimum thickness (mm)
SMA 6	20 – 40	15
SMA 10	25 – 50	20
SMA 14	35 – 50	30

### Surface Texture

16. Texture depth measurement shall be carried out in accordance with Clause 921. The test frequency shall be as specified in Appendix 1/5 but shall only be recorded for reference.
17. Where required by the Overseeing Organisation Grit sealant shall be applied, and shall be coarse aggregate mixture conforming sub-Clauses 972AR.2 and 972AR. It shall be machine applied as specified in Appendix 7/1 and/or Table 972AR/2. Where

required in Appendix 7/1 by the Overseeing Organisation it shall be coated with 40/60 grade bitumen.

Table 972 AR - 2 Composition of grit mixture		
Test Sieve	Proportion passing test sieve (% by mass)	
	2/4 particle size	1/2.8 particle size
8	-	-
6.3	100	-
4	90 – 100	100
2.8	-	90 – 100
2	0 – 25	-
1	-	0 – 25
0.63	0 – 2	0 – 2
Target binder content (%)	0.7 (+/- 0.5%)	1 (+/- 0.5%)
Machine application rate (kg/m <sup>2</sup> )	1 – 5 (for SMA 14)	1 – 1.25 (for SMA 6 and SMA 10)

18. The grit shall be applied from hoppers attached to a roller after the asphalt has been laid and after the initial compaction by roller. The rolling pattern shall, as far as practicable, provide a single application of grit to the full width with no overlap. When the material has reached ambient temperature, any surplus grit shall be removed carefully prior to the application of road markings and before the road is opened to traffic.

### Nominal Layer Thickness

19. Unless otherwise stated in Appendix 7/1 nominal compacted thickness shall be:

14mm      40mm

10mm      30mm

6mm      25mm when used as footway / cycle route surface course  
and 15 - 35mm when used as regulating layer.

### Reclaimed Asphalt

20. The use of reclaimed asphalt in SMA surface course shall be subject to approval from the Overseeing Organisation.

### NG 972 AR STONE MASTIC ASPHALT SURFACE COURSE

1. SMA with 10mm aggregate size has often been reported as the preferred option, offering good performance. Where surfacing system is used on the circulatory part of a roundabout or other gyratory junction, a maximum nominal aggregate size of 10mm should be used in the surfacing as research has demonstrated that it will provide greater durability.
2. The minimum PSVs to be applied to different categories of site and related to traffic flow are given in Table 3.1b of IAN 156/12. If, however, the measured skid resistance of the site when related to the life achieved and the skidding accident rate are below expectations for an aggregate from a particular source, then a higher PSV than that given in Table 3.1b of IAN 156/12 may be specified.
3. For new construction, the same levels of PSV must be used on different traffic lanes across the carriageway and in the hard shoulder. Where a single lane is being resurfaced for maintenance purposes the appropriate PSV shall be selected from Table 3.1b of IAN 156/12.
4. If the use of reclaimed asphalt is approved by the Overseeing Organisation, the best practice guide as described in TRL Road Note 43 should be followed.

### HMEP CL 973 AR RETREAD PROCESS

1. Unless otherwise specified by the Overseeing Organisation, Retread shall only be adopted for use on footways and lightly trafficked roads. Lightly trafficked roads typically carry no more than 5 millions of standard axle (msa) cumulative traffic.
2. Preliminary site investigations shall be carried out by the Contractor prior to the work to assess the consistency and condition of the existing pavement material. The site investigation shall at least include visual condition survey, coring assessments and determination of grading of the recovered aggregates.
3. The existing road surface should be pulverized, full width, up to a depth of about 75 mm. This pulverized material should then be worked using suitable tools such as reciprocating harrows and rollers to reduce it to a suitable grading with no material over 75 mm in size. If the grading is deficient in aggregate of one or more sizes, new aggregate may be added at this stage to rectify the grading. The surface shall then be reshaped to the required profile.
4. Depending on the grading and type of surface to be treated, bitumen emulsion conforming to BS EN 13808 C55 B 5 or C55 BF 5 should be applied by bulk distributor

conforming to BS 1707 at a total rate of 5.5 l/m<sup>2</sup> to 8 l/m<sup>2</sup> in two or three applications. After each application, except the last, the material should be mixed using suitable equipment to ensure good mixing and even distribution of the binder.

5. Following the last application of emulsion, the road should be reshaped if necessary and then rolled with an 8 t to 10 t deadweight roller. Any surface voids should be filled with either 8/14 mm or 6.3/10mm chippings applied at a suitable rate and rolled.
6. The surface should then be sealed by applying bitumen emulsion conforming to BS EN 13808 C60 B3, C60 BF3, C69 B3 or C69 BF3 at a rate of 0.9 l/m<sup>2</sup> to 1.2 l/m<sup>2</sup>, blinding with 2.8/6.3mm chippings and rolled.
7. If required, surface treatment (slurry seal, microsurfacing or surface dressing) may be applied to the retread layer.

### NG 974AR RETREAD PROCESS

1. Retread can be applied to pavements with any pre-existing condition, including those with rutting, cracking and potholes, as long as they have suitably good aggregate properties. However, Retread shall not proceed if the existing pavement aggregate has become substantially weathered, friable and/or contained deleterious material, and/or if the substrate or foundation has become unsound or in deteriorating condition.
2. Properties of the existing and new aggregates added to the retread layer and the new 6mm chipping shall comply with Clause 901.
3. The PSV of new 6mm chipping shall not be less than 50. Higher PSV may be required for a given Intervention Level (IL), traffic level and type of site; in this case, Table NG 971AR/1 or a local skid resistance policy may be used as guidance.
4. It is recommended that surface treatment should be applied within a year of completing the retread work. Typically there is a double dressing of 6.3/10mm aggregate.

**Example Appendix 7/1**

The following Appendix 7/1 has been prepared to illustrate the use of materials in various categories of highway from highly trafficked dual carriageway to farm access tracks.

## APPENDIX 7/1

## PERMITTED PAVEMENT OPTIONS

Notes on Appendix 7/1

1. The information in this appendix should be read in conjunction with drawings [ Insert relevant drawing numbers here ].
2. The Permitted Pavement Options are specified in Schedule 1.
3. General Requirements are specified in Schedule 2.
4. The Permitted Construction Materials are specified in Schedule 3.
5. General Requirements for Construction Materials are specified in Schedule 4.
6. Requirements for Construction Materials are specified in Schedule 5.
7. Thin Surface Course Systems: Information to be provided by the Contractor – Schedule 6.
8. At transitions between different pavement constructions, the surfacing with the highest specified PSV shall be laid over the length of the transition. On the immediate approach to roundabouts, this material shall extend to the Give Way line.
9. The surface course of lay-bys and bus lay-bys shall be ‘fuel resisting’.
10. The pavement options specified in this Appendix are those required to provide a 40-year design life, excluding PMA’s in which a 20 year design life is specified. Calculations of future design traffic were based on 2016 Annual Average Daily Traffic (AADT) values provided. Schedule 1 shows the ‘Actual traffic’ in million standard axles (msa) calculated for each area.
11. An equilibrium design CBR value of 3.0% was used for all pavement structures.
12. Schedule 3 lists all pavement options including foundation class and traffic range for each pavement option (in million standard axles). Note: Traffic in [brackets] indicates the actual traffic level where the pavement construction has been applied to maintain uniform construction between adjacent lanes.
13. Pavement Designs are designated, for example, as P3, P4 etc. The ‘P3’ simply denotes a unique pavement construction thickness and material type (e.g. P2 equates to 180mm DBM50, 200mm HBM-B and 260mm Class 3 Foundation material type).
14. Pavement Designs are subject to confirmation and Value Engineering, resulting from in-situ site testing, and where value engineering, e.g. by in-situ stiffness testing, demonstrates satisfactory performance; and in accordance with HD25 IAN 73/06, then value engineering results will be adopted.

15. Asphalt plantings may be used in accordance with the relevant Clauses in Specification of Highways Works (SHW) Series 800 and SHW Series 900 (specifically Clause 947 and 948). Also in accordance with TRL Report TRL 611.

## SCHEDULE 1 - PERMITTED PAVEMENT OPTIONS

Schedule 1: Permitted Pavement Options				
Drawing Ref	Area	PSV / AAV Values	Actual Traffic (msa)	Permitted Pavement Options
Insert Drawing Reference	Insert area defined on drawing or description of route	Insert PSV / AAV values for surface	Insert Traffic Figures	Insert Permitted Pavement Options
<i>002</i>	<i>Westernpool Junction – Realigned Ex. A4566</i>	<i>55/16</i>	<i>&lt;20 (AADF0027)</i>	<i>P3a</i>
<i>067</i>	<i>Lodge Lane Roundabout</i>	<i>55/16</i>	<i>&lt;20 (AADF0129)</i>	<i>P3b</i>
<i>001</i>	<i>Westernpool Junction – SB Merge Slip Road</i>	<i>60/16</i>	<i>&lt;20 (AADF0090)</i>	<i>P3c</i>
<i>013</i>	<i>Bestthorpe Ju – West Roundabout</i>	<i>60/16</i>	<i>≥20 &lt;40 (AADF0664)</i>	<i>P4</i>
<i>019 &amp; 020</i>	<i>Normandale Roundabout</i>	<i>65/14</i>	<i>≥80 (AADF2049)</i>	<i>P5</i>
<i>0004 &amp; 005</i>	<i>Roehoe Junction to Owthorpe Lodge</i>	<i>55/16</i>	<i>0.06 (AADF0001)</i>	<i>P9</i>
<i>016 &amp; 017</i>	<i>Cropwell Rd to Hardigate Rd Bway/Cycleway</i>	<i>N/A</i>	<i>No MSA (AADF0000)</i>	<i>P10</i>
<i>053 &amp; 054</i>	<i>Fields Farm Access Track</i>	<i>55/16</i>	<i>Indeterminate (AADF0001)</i>	<i>P11</i>
<i>007</i>	<i>Honeyfield Farm Morley Access</i>	<i>N/A</i>	<i>0.1 – 0.9 (AADF0010)</i>	<i>P12</i>
<i>008, 009 &amp; 048</i>	<i>Herrywell Lane Byway</i>	<i>N/A</i>	<i>0.06 (AADF0001)</i>	<i>P13</i>
<i>028</i>	<i>Occupation Lane - Restricted Byway</i>	<i>N/A</i>	<i>N/A</i>	<i>P14</i>

[ In the table above examples of its use are shown in italics ]

## Notes

1. For a minimum distance of 50m in advance of the 'Give Way' lines at roundabouts and T-junction, a specialised High Friction Surfacing (HFS) complying with Clause 924 should be provided, also complying with DMRB Volume 7 HD36/06. This may vary in some locations. Actual lengths will be shown on the project drawings.
2. For the 300m approach to diverge slip roads, also extending to the nosing; the mainline surface course shall incorporate aggregate with a PSV one step higher than that specified for the mainline carriageway.
3. Pavement options will be designed to the highest 'actual traffic' level value when adjacent lane has lower traffic.
4. Schedule 1 shows all recommended PSV and AAV values and should comply with Volume 7 Section 5 HD36/06, HD28, and any other relevant clauses. Schedule 1 shows AADF values (in brackets) for appropriate values to be selected. For PSV and AAV values concerned with individual geometric elements, e.g. gradients greater than 5% and horizontal curvature less than 500m consideration should be given to the increase of PSV and AAV to compensate for the need for additional skid and wear resistance. These areas should be marked in the project drawings.
5. General requirements refer to Schedule 2.

## SCHEDULE 2 - GENERAL REQUIREMENTS

Schedule 2: General Requirements Category A Road		
Grid for checking surface levels of pavement courses	Long. dims.	10m
	Trans. dims.	2m
Surface regularity	Categ. of Road:	A (Posted Speed Limit >50mls/hr)
Interval for measurement of transverse regularity. Continuous along each wheel track in each lane		Over the first 500m of completed surface course for each day of laying; transverse measurements shall be made at intervals not exceeding 20m. The 3m straight-edge should generally be placed centrally within the completed lane. Provided the results comply with SHW 702.8 (i.e. maximum allowable difference between straight-edge and pavement surface shall be 3mm) over this length, the test intervals may generally be increased to 100m. During testing, if any area is found not to comply with SHW 702.8, the Contactor shall be informed immediately and paving shall cease until the reasons for non-conformance are investigated and understood if the Supervisor considers that there is cause for concern. Steps should be taken to remedy the paving process if the Supervisor considers that there is cause for concern. Following any non-conformances, the test spacing shall revert to 20m, and may be extended to 100m once a consistent surface finish is being achieved.
Interval for measurement of transverse regularity		20m
Measurement of surface macrotexture is required		
Average:		As specified in Schedule 5, in this Appendix
Minimum:		As specified in Schedule 5, in this Appendix

Schedule 2: General Requirements Category B Road		
Grid for checking surface levels of pavement courses	Long. dims.	10m
	Trans. dims.	2m
Surface regularity	Categ. of Road:	B (Posted Speed Limit <40mls/hr)
Interval for measurement of transverse regularity. Continuous along each wheel track in each lane		Over the first 500m of completed surface course for each day of laying; transverse measurements shall be made at intervals not exceeding 20m. The 3m straight-edge should generally be placed centrally within the completed lane. Provided the results comply with SHW 702.8 (i.e. maximum allowable difference between straight-edge and pavement surface shall be 3mm) over this length, the test intervals may generally be increased to 100m. During testing, if any area is found not to comply with SHW 702.8, the Contactor shall be informed immediately and paving shall cease until the reasons for non-conformance are investigated and understood if the Supervisor considers that there is cause for concern. Steps should be taken to remedy the paving process if the Supervisor considers that there is cause for concern. Following any non-conformances, the test spacing shall revert to 20m, and may be extended to 100m once a consistent surface finish is being achieved.
Interval for measurement of transverse regularity		20m
Measurement of surface macrotexture is required		
Average:		As specified in Schedule 5, in this Appendix
Minimum:		As specified in Schedule 5, in this Appendix

- Note 1 Option P1 (320mm asphalt on Class 3 foundation): The combined asphalt layer thicknesses must be laid with a maximum of 6mm negative tolerance (i.e. 314mm total asphalt layer thickness).
- Note 2 Option P2 (180mm asphalt on 200mm HBM B on Class 3 foundation): The combined asphalt layer thicknesses must be laid with zero negative tolerance; and the HBM layer must be laid with zero negative tolerance.
- Note 3 All other Options: The combined asphalt layer thicknesses must be laid with zero negative tolerance.

Note 4      Reference and compliance to Specification for Highway Works, Series 900, Clause 921 for Surface Macrotexture of Bituminous Surface Courses.

## SCHEDULE 3 - PERMITTED CONSTRUCTION MATERIALS

Permitted Construction Materials	Pavement Option P1 (Class 3 Foundation)		Pavement Option P2 (Class 3 Foundation)	
	Fully Flexible (FF) (Traffic Range 126-190msa)		Flexible Composite (FC) (Traffic Range 126-190msa)	
Pavement Layer	Material Ref	Thickness	Material Ref	Thickness
Surface Course	TSC	30mm	TSC	30mm
Binder Course	DBM50/ HDM50	60mm	DBM50/ HDM50	60mm
Upper Base	-	-	DBM50/ HDM50	90mm
Base	DBM50/ HDM50	230mm	HBM B	200mm
Lower Base	-	-	-	-
Foundation <i>(Layer Stiffness)</i> <i>[Surface Modulus]</i>	SB1	250mm <i>(750MPa)</i> <i>[≥200MPa]</i>	SB1	250mm <i>(750MPa)</i> <i>[≥200MPa]</i>
Running Layer	-	300mm* <sup>1</sup>	-	300mm* <sup>1</sup>
Total Thickness	570mm		630mm	
PSV/AAV	Refer to Schedule 1 & the Drawing Series for PSV/AAV values at road locations specific to geometric and traffic conditions.			

Permitted Construction Materials	Pavement Option P3a (Class 2 Foundation)		Pavement Option P3b (Class 2 Foundation)		Pavement Option P3c (Class 2 Foundation)	
	Fully Flexible (FF) (Traffic Range $\leq 2\text{msa}$ )		Fully Flexible (FF) (Traffic Range 2-5msa)		Fully Flexible (FF) (Traffic Range 5 - 20msa)	
Pavement Layer	Material Ref	Thickness	Material Ref	Thickness	Material Ref	Thickness
Surface Course	TSC	30mm	TSC	30mm	TSC	30mm
Binder Course	DBM50	60mm	DBM50	60mm	DBM50	60mm
Upper Base	-	-	-	-	-	-
Base	DBM50	110mm	DBM50	150mm	DBM50	200mm
Lower Base	-	-	-	-	-	-
Foundation <i>(Layer Stiffness)</i> <i>[Surface Modulus]</i>	SB2	320mm <i>(150MPa)</i> <i>[<math>\geq 100\text{MPa}</math>]</i>	SB2	320mm <i>(150MPa)</i> <i>[<math>\geq 100\text{MPa}</math>]</i>	SB2	320mm <i>(150MPa)</i> <i>[<math>\geq 100\text{MPa}</math>]</i>
Running Layer	-	-	-	-	-	-
Total Thickness	520mm		560mm		610mm	
PSV/AAV	Refer to Schedule 1 & the Drawing Series for PSV/AAV values at road locations specific to geometric and traffic conditions.					

Permitted Construction Materials	Pavement Option P4 (Class 2 Foundation)		Pavement Option P5 (Class 2 Foundation)		Pavement Option P6 PMA requiring sealing with occasional HGVs	
	Fully Flexible (FF) (Traffic Range 20-40msa)		Fully Flexible (FF) (Traffic Range $\geq$ 40msa)		PMA Surface Paved (Traffic Indeterminate msa)	
Pavement Layer	Material Ref	Thickness	Material Ref	Material Ref	Thickness	Material Ref
Surface Course	TSC	30mm	TSC	TSC	30mm	TSC
Binder Course	DBM50	60mm	DBM50	DBM50	60mm	DBM50
Upper Base	-	-	-	-	-	-
Base	DBM50	230mm	DBM50	DBM50	230mm	DBM50
Lower Base	-	-	-	-	-	-
Foundation <i>(Layer Stiffness)</i> <i>[Surface Modulus]</i>	SB2	320mm <i>(150MPa)</i> <i>[<math>\geq</math>100MPa]</i>	SB2	SB2	320mm <i>(150MPa)</i> <i>[<math>\geq</math>100MPa]</i>	SB2
Running Layer	-	-	-	-	-	-
Total Thickness	640mm		680mm		275mm	
PSV/AAV	Refer to Schedule 1 & the Drawing Series for PSV/AAV values at road locations specific to geometric and traffic conditions.					

Permitted Construction Materials	Pavement Option P7 Sub-base track Bridleway & occasional heavy use		Pavement Option P8 Paved Track with use by HGVs		Pavement Option P9 Trafficked Bridleway & Cycleway Track	
	PMA Stone Track (Traffic 0.06msa approx)		PMA Paved (Traffic 0.1 - 0.9msa approx)		Cycleway & Bridleway Paved (Traffic 0.06msa approx)	
Pavement Layer	Material Ref	Thickness	Material Ref	Material Ref	Thickness	Material Ref
Surface Course	-	-	-	-	30mm	TSC
Binder Course	-	-	DBM50	DBM50	60mm	DBM50
Upper Base	-	-	-	-	-	-
Base	-	-	-	-	230mm	DBM50
Lower Base	-	-	-	-	-	-
Foundation <i>(Layer Stiffness)</i> <i>[Surface Modulus]</i>	SB3	300mm	SB3	SB3	320mm <i>(150MPa)</i> <i>[≥100MPa]</i>	SB2
Running Layer	-	-	-	-	-	-
Total Thickness	300mm		440mm		385mm	
PSV/AAV	Refer to Schedule 1 & the Drawing Series for PSV/AAV values at road locations specific to geometric and traffic conditions.					

Permitted Construction Materials	Pavement Option P10 Non-trafficked Bridleway & Cycleway Track		Pavement Option P11		Pavement Option P12 Concrete Farm Access	
	Cycleway & Bridleway Paved (No Actual Traffic)		PMA Surface Paved (Traffic Indeterminate msa)		Rigid Construction (Traffic 0.1 - 0.9msa approx)	
Pavement Layer	Material Ref	Thickness	Material Ref	Material Ref	Thickness	Material Ref
Surface Course	-	-	DBM 125	-	-	DBM 125
Binder Course	DBM50	60mm	DBM50	DBM50	60mm	DBM50
Upper Base	-	-	-	-	-	-
Base	-	-	-	-	-	-
Lower Base	-	-	-	-	-	-
Foundation <i>(Layer Stiffness)</i> <i>[Surface Modulus]</i>	SB3	100mm	SB3	SB3	100mm	SB3
Running Layer	-	-	-	-	-	-
Total Thickness	160mm		315mm		645mm	
PSV/AAV	Refer to Schedule 1 & the Drawing Series for PSV/AAV values at road locations specific to geometric and traffic conditions.					

Permitted Construction Materials	Pavement Option P13		Pavement Option P1 (Class 4 Foundation)		Pavement Option P2 (Class 4 Foundation)	
	Forestry Track By Agreement (Traffic Indeterminate msa)		Fully Flexible (FF) (Traffic Range 126-190msa)		Flexible Composite (FC) (Traffic Range 126-190msa)	
Pavement Layer	Material Ref	Material Ref	Thickness	Material Ref	Thickness	Material Ref
Surface Course	Asphalt Planings	TSC	30mm	TSC	30mm	DBM 125
Binder Course	-	DBM50/ HDM50	60mm	DBM50/ HDM50	60mm	DBM50
Upper Base	-	-	-	-	-	-
Base	-	DBM50/ HDM50	190mm	DBM50/ HDM50	190mm	-
Lower Base	-					-
Foundation <i>(Layer Stiffness)</i> <i>[Surface Modulus]</i>	Capping layer	Class 4	To be determined	Class 4	To be determined	SB3
Running Layer	-					-
Total Thickness	550mm/670mm					
PSV/AAV	Refer to Schedule 1 & the Drawing Series for PSV/AAV values at road locations specific to geometric and traffic conditions.					

\*With AEA to give 3.5% air voids

## SCHEDULE 4 – GENERAL REQUIREMENTS FOR CONSTRUCTION MATERIALS

Schedule 4: General Requirements for Construction Materials	
Clause	Requirement
-	<b>NOT USED</b>

## SCHEDULE 5 - REQUIREMENTS FOR CONSTRUCTION MATERIALS

Schedule 5: Requirements for Construction Materials			
Material Ref.	Clause	Description	Requirement
SB1	Series 890 – 896. Performance Based Foundation Design in accordance with DMRB HD25 Interim Advice Note 73/06.	<u>Foundation Class 3</u> on a subgrade design value of 3% CBR.	<u>Foundation Class 3 with a Long-term in service Surface Stiffness Modulus of 200MPa, or above.</u> SB1 material Layer Stiffness of 750MPa, or above. All performance stiffness values to be proved by contractor by trial tests in a demonstration area, prior to construction.
SB2	Series 890 – 896. Performance Based Foundation Design in accordance with DMRB HD25 Interim Advice Note 73/06.	<u>Foundation Class 2</u> on a subgrade design value of 3% CBR.	<u>Foundation Class 2 with a Long-term in service Surface Stiffness Modulus of 100MPa, or above</u> SB2 material Layer Stiffness of 150MPa, or above. All performance stiffness values to be proved by contractor by trial tests in a demonstration area, prior to construction. Where the traffic is in excess of 80msa, a minimum of 150mm upper bound sub-base is to be used (ref. DMRB Volume 7 HD26/06, Cl.2.8).
SB3	Series 800 Guidance, MCHW Vol.2	<u>Sub-base</u>	In accordance with series 800. BS EN 13285
HFS	Series 900-924	High Friction Surfaces	Type Classification: 1 Minimum PSV: 70+

Schedule 5: Requirements for Construction Materials				
Material Ref.	Clause		Description	Requirement
HDM50 Binder Course	AC 20 HDM bin 40/60	Series 900- 929	HDM Binder Course Asphalt Concrete (Design Mixtures)	Stone Size: 20mm Penetration Range 40 to 60dmm BS 594987:2007 BS EN 13108 BSI PD 6691:2007 Annex B
HDM50 Base Course	AC 32 HDM base 40/60	Series 900- 929	HDM Base Course Asphalt Concrete (Design Mixtures)	Stone Size: 32mm Penetration Range 40 to 60dmm BS 594987:2007 BS EN 13108 BSI PD 6691:2007 Annex B
DBM12 5	AC6 bin 100/150 or 70/100	Series 900-929	Asphalt Concrete Dense Surface Course	Stone Size: 6mm Penetration Range 100 to 150dmm OR 70 to 100dmm BS EN 12591
DBM50 Binder Course	AC 20 bin 40/60 des	Series 900- 929	DBM Binder Course Asphalt Concrete (Design Mixtures)	Stone Size: 20mm Penetration Range 40 to 60dmm BS 594987:2007 BS EN 13108 BSI PD 6691:2007
DBM50 Base Course	AC 32 base 40/60 des	Series 900-929	DBM Base Course Asphalt Concrete (Design Mixtures)	Stone Size: 32mm Penetration Range 40 to 60dmm BS EN 13108 BS 594987:2007 BSI PD 6691:2007
HBM B	Series 800 – 810 - 840		Hydraulically Bound Mixture	HBM B in accordance with DMRB HD26/06.
SD	TRL Road Note 39		Surface Dressing	Single surface dressing 6mm stone at 1.4l/m2 binder application TRL Report № 39 BS EN 13043 BS EN 598-1081

Schedule 5: Requirements for Construction Materials			
Material Ref.	Clause	Description	Requirement
TSC	Series 900 - 942	Thin Surface Course Systems	<p>Refer to Schedule 1 and Notes for PSV and AAV values.</p> <p>Minimum wheel tracking level required on British Board of Agrément HAPAS Roads and Bridges Certificate: Level 3</p> <p>Minimum initial texture depth shall be in accordance with Table 9/3 under clause 921 MCHW, Volume 1 SHW.</p> <p>Road/Tyre noise level of the Thin Surface Course System shall be Level 2, in accordance with Table NG 9/30, under clause 942 MCHW, Volume 1 SHW.</p> <p>BS EN 13036-1</p> <p>BS EN 594987, Clause 8.2</p> <p>The texture depth Guarantee shall be 2 years to Clause 942.14.</p> <p>Surface Integrity-Performance Guarantee shall be 5 years to Clause 942.16.</p>
		Hot Rolled Asphalt	<p>Refer to Schedule 1 and Notes for PSV and AAV values.</p> <p>Road/tyre noise level relative to hot rolled asphalt required on British Board of Agrément HAPAS Roads and Bridges Certificate: Level 2.</p> <p>Minimum initial texture Depth shall be in accordance with Table 9/3 under clause 921 MCHW, Volume 1 SHW.</p> <p>Guarantee Period: 5 years</p>

Note 1 Option P1 (320mm asphalt on Class 3 foundation): The combined asphalt layer thicknesses must be laid with a maximum of 6mm negative tolerance (i.e. 314mm total asphalt layer thickness).

- Note 2 Option P2 (180mm asphalt on 200mm HBM B on Class 3 foundation): The combined asphalt layer thicknesses must be laid with zero negative tolerance; and the HBM layer must be laid with zero negative tolerance.
- Note 3 All other Options: The combined asphalt layer thicknesses must be laid with zero negative tolerance.
- Note 4 Reference and compliance to Specification for Highway Works, Series 900, Clause 921 for Surface Macrotexture of Bituminous Surface Courses.

#### **SCHEDULE 6 - THIN SURFACE COURSE SYSTEMS: INFORMATION TO BE PROVIDED BY THE CONTRACTOR**

The Contractor shall provide the following information prior to commencement of the Works:

- (i) A copy of the British Board Agrément HAPAS Roads and Bridges Certificate, or approved CE approved equivalent, for the thin surface course system or systems that are proposed for use in the works, together with a copy of the Quality Plan and Installation Method Statement associated with each Certificate [*Clause 942.1*]
- (ii) For any Certificate that covers several variants of one thin surface course system, proposed variant or variants of the system to be used in the Works [*variants of a system occur from any option that results in different values being reported on the Certificate for one or more properties, and could involve changes in nominal maximum aggregate size, aggregate type, aggregate grading, binder type, binder content, fibres or other additives*].
- (iii) If requested, or if the thin surface course system is not produced under a sector Scheme, the proposed component materials to be used in the thin surface course system and their proportions for each proposed system [*Clause 924.2*].
- (iv) Proposed source or sources of coarse aggregate together with statement of properties including Polished Stone Value (PSV), Los Angeles Coefficient (LAC), aggregate abrasion value and flakiness index [*Clause 942.5*].
- (v) If regulating material is to be used, evidence of its deformation resistance either independently or in combination with the thin surface course system [*Clause 942.10*].

## SERIES 1100 – FOOTWAYS AND PAVED AREAS

The HMEP specification brief is directed towards the identification of potential cost savings through the standardisation of materials, and was originally limited to bituminous materials. Following review of the information provided by the contributing local authorities it became apparent that alterations to the Manual of Contract Documents for Highways Works and Specification for Highways Works for series 1100 were limited. The brief was expanded to cover general footway works, drawing on examples of good practice provided by contributing authorities.

From the specification examples provided it was found that, although there were a number of variations from the Manual of Contract Documents for Highways Works and Specification for Highways Works standard clauses these could be attributed to individual projects or local variations. For the purposes of the project these were considered in light of their possible provenance and a judgement on their use taken, based upon common themes from other authorities.

Substantial variations to precast concrete materials (kerbs and paving stones) were not found in the material provided by the contributing authorities, and as a result it was decided to remove this item from work under this project. Variations in flexible materials are dealt with in Series 900 – Bituminous Bound Materials.

One area where a need for additional information was identified was in the provision of standard detail drawings for footways. This area is absent from the Manual of Contract Documents for Highways Works, Highways Construction Details.

The table below lists the current clauses from the Specification for Highways Works and alternate Clauses developed by the HMEP for local highway authority use. As noted above, in addition a range of standard detail drawings have been developed to cover the detailing of footway works for local highway authorities.

Series 1100 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
1101	Precast Concrete Kerbs, Channels, Edgings and Quadrants	1101 SR	Precast Concrete Kerbs, Channels, Edgings and Quadrants
1102	(11/04) In-Situ Asphalt Kerbs	-	-
1103	(11/04) Freestanding In-Situ Concrete Kerbs, Channels and Edge Details	-	-
1104	(05/01) Footways and Paved Areas (Precast Concrete Flags and Natural Stone Slabs)	1104 SR	Footways and Paved Areas (Precast Concrete Flags and Natural Stone Slabs)
1105	(11/04) Footways and Paved Areas (Flexible Surfacing)	1105 SR	Footways and Paved Areas (Flexible Surfacing)
1106	(11/04) Footways and Paved Areas (In-Situ Concrete)	-	-
1107	Footways and Paved Areas (Concrete Block Paving)	-	-
1108	Footways and Paved Areas (Clay Pavers)	-	-
1109	(11/04) Grass Concrete Paving	-	-
1110	(05/01) Access Steps	-	-
-	-	1170 AR	Frost Susceptibility
-	-	1171 AR	Footway Slurry Sealing
-	-	1172 AR	Wheel Chair Ramps
-	-	1173 AR	Timber Edging

## HMEP CL 1101 SR - PRECAST CONCRETE KERBS, CHANNELS, EDGINGS AND QUADRANTS

1. Except where otherwise specified in this Clause, precast concrete kerbs, channels, edgings and quadrants shall conform to BS EN 1340 and their dimensions, type designations and performances and classes shall be as described in this Clause and Appendix 11/1. They shall be laid and bedded in accordance with BS 7533-6 on a mortar bed on a concrete pavement slab, a base or a C6/8 or ST1 in accordance with BS 8500-2 concrete foundations. The mortar bed may be omitted if units are bedded onto a concrete slab or foundation that is still plastic. All precast units laid on a mortar bed or bedded onto plastic concrete shall be backed with a strength class C6/8 or ST1 concrete in accordance with BS 8500-2.
2. Precast concrete kerbs, which are to be bonded to the pavement surface, shall conform to BS EN 1340. The bonding materials and methods of bonding shall be to the manufacturer's recommendations for this specific application. Bonded kerbs shall not be less than 100 mm in width at the base, their height shall not exceed their width and they shall be bonded over their full width. Kerbs shall be precast to the dimensions described in Appendix 11/1. The clear distance between unsupported pavement edge and back of kerb shall be not less than 100 mm. The bending strength of units shall be established by testing in accordance with BS EN 1340 and shall not be less than class 2 in Table 3 of BS EN 1340. Units shall be installed in accordance with the manufacturer's instructions. They shall be bonded to the pavement surface with a resilient adhesive compatible with the pavement materials and be capable of withstanding a static push-off load of 10 kN/m applied parallel to the pavement surface at right angles to the kerb.
3. Joints shall be provided in kerbs, channels, edgings and backing, which are laid on or adjacent to a concrete pavement to coincide with the pavement transverse contraction, warping and expansion joints. The joints shall be the same width as the joint sealing grooves of the pavement and shall be caulked and sealed as described in Clauses 1016 and 1017. Concrete foundations to kerbs, channels and edgings laid adjacent to a concrete pavement shall be provided with joint filler board complying with Clause 1015 placed vertically through the full extent of the concrete foundation at positions coinciding with the pavement joints. At expansion joints in bridge decks, the kerb joints shall be as described in Appendix 11/1. Where the details of bridge expansion joints are proposed by the Contractor, such details shall include the intended treatment at kerbs and footways.
4. For curves of radius 12 m or less, kerbs of appropriate radius shall be used as per BS EN 1340. For radii of 12m to 25m, 600mm long straight kerbs may be used. However no single kerb shall be less than 450mm long.
5. The surface level of units of kerb, channel, edging and quadrant shall not deviate from the design level  $\pm 6$  mm, nor shall the longitudinal surface regularity deviate more than 3 mm in 3 m when checked with a 3 m straight edge. Horizontal alignment shall comply with Clause 702.

6. The construction principles and practices set out in sub clauses 1-5 above shall apply equally to granite and stone kerbs and setts laid in kerb lines, except that the tolerances for longitudinal and vertical accuracy shall be  $\pm 6\text{mm}$  along the top outer edge of the kerbs to allow for local irregularities in shape.

## HMEP CL 1104 SR FOOTWAYS AND PAVED AREAS (PRECAST CONCRETE FLAGS AND NATURAL STONE SLABS)

1. Precast concrete flags shall conform to BS EN 1339. Natural stone slabs shall conform to BS EN 1341. Type designations, thicknesses and performances and classes shall be as described in Appendix 11/1.
2. Precast concrete flags and natural stone slabs shall be laid in accordance with BS 7533-4, to the required cross falls with a bond as described in Appendix 11/1 and with joints at right angles to the kerb. Flags and natural stone slabs shall be bedded on a layer of mortar not less than 10 mm and not more than 40 mm thick. Where permitted in Appendix 11/1, flags and natural stone slabs 450 mm x 450 mm and smaller may be laid on a layer of sand conforming to BS EN 12620 designation 0/4 mm, 25 mm  $\pm$  5 mm thick. Joints to be filled with sand conforming to BS EN 12620 designation 0/2.
3. On circular work where the radius is 12 m or less all flags and natural stone slabs shall be radially cut on both edges to the required line.
4. The laying course shall be laid on sub-base composed of one of the materials complying with Clause 803, 804, 805, 806, 821, 822 or 823, laid and compacted to Clause 802 or 813 as appropriate and to the thickness described in Appendix 11/1.
5. Precast concrete slabs shall be cut by machine where it is necessary to accommodate ironwork, lamp columns and other street furniture within the footway. To avoid undue cutting, a granolithic concrete (Clause 2607) fillet, 65mm thick and not exceeding 75mm in width, may be used to fill gaps between the flags and faces of existing boundary walls or buildings.
6. The granolithic concrete shall be fully compacted and brush finished. Granolithic concrete fillets 65mm thick and not exceeding 200mm wide may be used around ironwork, lamp columns, etc, at the discretion of the Overseeing Organisation.
7. Where flags or slabs are used on circular work with radii of 12m or less then flags should be radially cut on both edges.
8. Where tactile paving is to be used it shall be done so in accordance with the document "Guidance on the use of tactile paving surfaces" (DfT, December 2005). As a general rule, tactile paving used at controlled crossings should be red whilst the colour at uncontrolled crossings should be buff unless specified otherwise by the Overseeing Organisation.

## HMEP CL 1105 SR - FOOTWAYS AND PAVED AREAS (PRECAST CONCRETE FLAGS AND NATURAL STONE SLABS)

1. Flexible surfacing and sub-base for footways and paved areas shall be constructed using the materials and layer thicknesses described in Appendix 11/1.
2. Bituminous mixtures used in flexible surfacing shall be made in accordance with BS EN 13108, the detailed requirements from the example specifications in BS PD6691 and Clause 901.
3. Flexible surfacing shall be laid and compacted in accordance with BS 594987. Sub-base shall be composed of an unbound mixture conforming to Clause 803, 804, 805, 806, or 807 or a cement bound granular mixture conforming to Clause 821, 822 or 823. Sub-base shall be laid and compacted to Clause 802 or 813, as appropriate.
4. The permitted tolerance for the finished surface of footway binder course layers shall be -6 mm to +0 mm and for footway surface course layers shall be - 0 to + 6 mm.
5. The sealing of joints in surfacing or edges of repairs shall be by painting of the vertical face only (in accordance with Clause 901) and shall not include overbanding or surface applied sealing unless so directed by the Project Manager.

## HMEP CL 1170AR – FROST SUSCEPTIBILITY

Subject to the tolerances given in Table 7/1 and unless otherwise stated in Appendix 7/1, material shall not be frost susceptible if it is used within 450mm of the designed final surface of a footway or paved area, or 350mm if the mean annual frost index of the site is less than 50. Material shall be classified as non-frost susceptible if the mean heave is 15mm or less, when tested in accordance with BS 812: Part 124: 1989 amended as given in Sub Clauses 801.7 and 801.8.

## HMEP CL 1171AR – FOOTWAY SLURRY SURFACING

Footway Slurry Surfacing should be undertaken in accordance with Clause 918. Hand laying and brush-texturing is permitted under sub clause 918.21. Mixing of materials in small batches is covered by sub clauses 918.16.

### HMEP NG 1171AR SLURRY SURFACING

1. Treat all emergent weeds, with an approved herbicide, 7 to 14 days prior to the application of the surfacing and in accordance with manufacturers' instructions. Rake out and remove all dead weeds, side back grass and clear back overhanging vegetation immediately prior to the application of the surfacing.
2. The full width and length of the area to be treated shall be covered without overlapping kerbs, channels and edgings for footways.
3. Immediately before application of the surfacing all loose material from the surface to be covered and any remaining vegetation still growing shall be removed, with any remaining root growth treated with an approved herbicide.
4. The material shall not be allowed to overlap on to boundary walls fences or any other structure adjoining the highway nor any street furniture actually situated within the areas to be treated. All ironwork such as manhole covers, hydrants, gullies, catchpit covers, stop valves or similar shall be masked to give complete protection during the operation. Oils, and/or sand or similar materials shall not be used.
5. Longitudinal joints shall be feather lapped such that the joints do not exceed the nominal layer thickness, longitudinally or laterally. Joints with adjacent surfaces shall be feathered to neat regular shapes appropriate to the layout, and protective mats or paper should be used to achieve same. In every case, surfacing of the highest part of the substrate due to crossfall or camber will always be treated last thereby ensuring that the upper layer of the feather lap at joints will be so formed to shed water towards the lower section of surface.

### HMEP CL 1172AR – WHEELCHAIR RAMPS

Ramps shall have a maximum gradient of 1 in 12 relative to the adjacent surfaces. They shall extend across the full width of the footway unless a minimum clear width of 900mm can be achieved behind the ramp. Where possible all ramps shall be positioned to avoid ironwork in the footway and/or channel.

### HMEP CL 1173AR – TIMBER EDGING

1. Timber edging and supporting stakes shall be band sawn, knot free softwood which shall be certified to have been pressure treated / tanalised with a net retention of tanalisation in the timber of not less than 160kg per cubic metre.
2. Edgings shall either be fixed and supported by wood stakes or laid and bedded in concrete class ST3.

3. Where the edgings are to be curved to achieve tighter radii they may be notched to a maximum depth of  $1/3^{\text{rd}}$  the thickness of the edging on the inside of the radius prior to pressure treatment.

### **NHSS 30 – The National Highways Sector Scheme for the Installation, Maintenance and Repair of Modular Paving.**

Interlay is developing a new National Highways Sector Scheme for the Installation, Maintenance and Repair of Modular Paving. This new scheme will improve the installed quality of all types of modular paving products by:

- Providing an industry benchmark.
- Ensuring that all processes are planned.
- Providing a basis for continuous improvement.
- Focusing on quality as an objective.
- Reducing overall costs for the client and supplier.
- Providing and maintaining a properly trained and competent workforce.
- Involving all sides of the industry in scheme ownership within a partnership framework.
- Ensuring that Certification Bodies are used whose auditors with technical knowledge and experience of the sector concerned.
- Promoting confidence in quality management systems by provision of a robust, transparent system.

The release date of the new sector scheme is not available at present, but it is felt that additional work in this project on modular paving will be replaced by the scheme in the near future. As a result no work on modular paving has been undertaken.

## SERIES 1200 – TRAFFIC SIGNS – ROAD MARKINGS AND ROAD STUDS

The HMEP specification brief is directed towards the identification of potential costs savings through the standardisation of materials, and was limited to road marking materials and road studs for this section of the project. From the information received from contributing authorities for it became apparent that alterations to the Manual of Contract Documents for Highways Works and Specification for Highways Works for road markings and road studs were limited, and associated to individual projects rather than the procurement of bulk works.

The contents list below lists the current Clauses from the Specification for Highways Works. Following review of the information provided by local highways authorities and other external bodies for this brief it is considered that the current Specification for Highways Works should be used for this Series.

### Contents List

Series 1200 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
1201	Regulations, Sign Classification and Standards	-	-
1202	General Requirements for Permanent Traffic Signs	-	-
1203	Foundations for Permanent Traffic Signs and Signals	-	-
1204	Posts for Permanent Traffic Signs	-	-
1205	Sign Plates for Permanent Traffic Signs	-	-
1206	Faces for Permanent Traffic Signs	-	-
1207	Construction and Assembly of Permanent Traffic Signs	-	-
1208	Location and Erection of Permanent Traffic Signs	-	-
1209	Covering of Permanent Traffic Signs	-	-

<b>Table Continued</b>			
<b>Clause Number</b>	<b>Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works</b>	<b>HMEP Clause Number</b>	<b>Highways Maintenance Efficiency Programme</b>
1210	Permanent Bollards	-	-
1211	Permanent Marker Posts	-	-
1212	(05/01) Road Markings	-	-
1213	(05/01) Road Studs	-	-
1214	Traffic Cones, Traffic Cylinders, Flat Traffic Delineators and Other Traffic Delineators	-	-
1215	Road Danger Lamps and High Intensity Flashing Beacons	-	-
1216	Temporary Traffic Signs	-	-
1217	Traffic Signals	-	-
1218	Detector Loops	-	-
1219	Controlled and Un-controlled Crossings	-	-
1220	Traffic Signs on Gantries	-	-
1221	Preparation and Finish of Metal and Other Surfaces	-	-

#### **ADDITIONAL GUIDANCE**

Guidance has been issued by ADEPT (ex County Surveyors Society) on the inspection of road markings and road studs, and accessed at their website.

**HMEP AG 1300 001- LATD 26/05 INSPECTION OF ROAD MARKINGS AND ROAD STUDS**

## SERIES 1300 – ROAD LIGHTING COLUMNS AND BRACKETS

The HMEP specification is directed towards the identification of potential cost savings through the standardisation of materials, and was limited to Road Lighting Columns and Brackets for this section of the project. Examination of lighting units, luminaires and electrical systems were excluded from the project.

Limited information was available from contributing authorities for these works, and following further investigation it became apparent that many authorities had delegated the specification of lighting units to specialist maintenance contractors. The one area that was identified as a possible source of saving was through the standardisation of road lighting column units. This was originally identified by the Eastern Shires Purchasing Organisation, and was developed to provide a greater column lifespan to promote long-term savings in column replacement.

Another factor that was identified that may save cost with respect to the design of a lighting column is the diminishing requirement for long bracket arms. With the improvement of luminaire design and technology the projection of a bracket has significantly reduced.

The contents list below lists the current Clauses from the Specification for Highways Works and alternate Clauses developed by the HMEP for local highways authority use. In addition a range of standard detail drawings have been developed to cover the detailing of lighting columns to the specification below, that may be used on local authority highways.

### Contents List

Series 1300 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
1301	(05/01) General	1301 SR	General
1302	(11/03) Design of Lighting Columns, Brackets, CCTV Masts, Cantilever Masts, Foundations, Anchorages and Attachment Systems	1302 SR	Design of Lighting Columns, Brackets, CCTV Masts, Cantilever Masts, Foundations, Anchorages and Attachment Systems
1303	(05/01) Data Sheets	-	-

<b>Table Continued</b>			
<b>Clause Number</b>	<b>Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works</b>	<b>HMEP Clause Number</b>	<b>Highways Maintenance Efficiency Programme</b>
1304	(05/01) Identification and Location Markings	1304 SR	Identification and Location Markings
1305	Installation of Foundations, Anchorages and Attachment Systems	-	-
1306	Site Tests on Anchorages in Drilled Holes	-	-
1307	Materials and Surface Finishes	-	-
1308	(05/01) Handling, Transport and Erection	1308 SR	Handling, Transport and Erection
1309	(11/04) Amendments and Additions to BS 5649-2: 1978 (AMD 3136, 1979) for Lighting Columns	-	-
1310	(11/04) Amendments and Additions to BS EN 40-5 and BS EN 40-6 for Lighting Columns and Brackets, CCTV Masts and Cantilever Masts	-	-
1311	(11/04) Amendments and Additions to BS 5649-5 for Lighting Columns, CCTV Masts and Cantilever Masts	-	-
1312	(11/03) Attachments to Lighting Columns, CCTV Masts and Cantilever Masts	-	-
1313	(05/01) Laminated Glass Fibre Reinforced Plastic (GFRP) Lighting Columns	-	-
1314	Brackets for Laminated GFRP Lighting Columns	-	-

## HMEP CL 1301 SR GENERAL

The Specification for Highway Works (SHW) is the background for this series. Columns shall not have holes drilled or stamped out of them unless they are designed for purpose by the manufacturer. Reference to the standard detail for manufacture purposes shall apply throughout.

All components shall be supplied by an accredited company to NHSS6 and ISO9001 and provide a copy of the appropriate accreditation prior to any purchases and erection of equipment.

### Tubular Steel Column Specification:

1. The design, manufacture and supply of steel lighting columns shall comply with the requirements of BS EN 40 parts 1 – 3, and 5:
  - a) Hot finished circular hollow sections to EN10210 part 1 grades S275 & S355 JOH .
  - or
  - b) Cold formed circular hollow sections without subsequent heat treatment to the requirements of EN10219 part 2 and to the mechanical and chemical properties of EN 10219 part1 grade S275 JOH or S355 JOH. The hot finished feedstock material shall comply with the yield, tensile and elongation requirements given in BSEN 10025.
  - c) All tube stock shall be new.

The lighting column shall be single stepped, parallel tubular steel. The first reduction starting from above base compartment and have a single shaft to the mounting height of the column.

Any spigot reduction should finish at 76.0 mm diameter for 5, 6, 8, 10 & 12 m columns to BS EN 40-2 the spigot length should be a minimum of 210mm including the cut-out for the castellation that accommodates the anti rotation bar of the bracket arm for columns 8m and above.

2. Bracket arms shall comply with section annex A of BS EN 40 together with the 'Specification for Highway Works' series 1300 and have a maximum projection of 1.0m. The bracket spigot shall be a minimum o/d of 42.3mm x 100mm in length. The bracket tube size will be designed suitable to support the chosen lantern weight. NHSS 6 certification for both manufacturer and distributor is to be presented along with calculations at time of enquiry.
3. All columns shall have wrap around type doors with a formed edge return and have an engineered solution to retain the door when removed and be of sufficient length to allow the door to lay flat on the ground. The door fixing screw shall be a minimum of M8 thread and be stainless steel with a triangular head. The door shall align with the aperture in one easy action. Where a threaded fixing hole for the door fixing screw is adopted then the screw should be easily located into the hole. The door

must be steel and may be of a thinner material than the column tube to assist weight but not be less than 2mm thick.

4. Columns shall be galvanised to BSEN1461.
5. The steel tube material thickness shall be a minimum of 4.0mm.
6. The root protection shall be applied as follows:
  - a) Pre-treat galvanised external surface of the column with Dacrylate “T” Wash ref: 150-23 application to be fully in accordance with Dacrylate Technical Data Sheet (shop applied).
  - b) Apply one coat of Epidac 2 HB Aluminium Epoxy Item 115 re 90-268 to the external surface of the column root to 250mm above ground level minimum DFT 125 µm colour metallic aluminium (shop applied).
  - c) Apply one coat of Epidac 2 Glass Reinforced Epoxy ref 79-489 to the external surface of the column root to 250mm above ground level minimum DFT 200 µm. Colour metallic aluminium (shop applied).
7. New columns shall not be used to support catenary cables, attachments or traffic signs above 0.3 m<sup>2</sup> unless specifically designed for that purpose.

## HMEP CL 1302 SR - DESIGN OF LIGHTING COLUMNS, BRACKETS, FOUNDATIONS, ANCHORAGE'S AND ATTACHMENT SYSTEMS

1. The column shall be designed and manufactured to the most current version of BS EN 40 1-3 & 5 including PD 6547 +A1 2009 from details of the design shall be presented for approval prior to installation in accordance with Clause 1303 of the Specification for Highways Works.
2. The foundation design shall be undertaken by the installer or the installer's representative based on the ground conditions and the overturning moment of the column for the given sheer force of the column based on the manufacturers' data of the chosen column type.
3. Prior to the purchase of the Lighting columns the following information shall be sourced:
  - The column shall be manufactured with a Terrain Category suitable for the installation environment and selected from PD6547 +A1 2009.
  - The 10 minute wind velocity.
  - The maximum altitude for the installation.
  - The category of rationalised wind loading.
  - Ground conditions/factor.
  - Luminaire weight and profile wind resistance or shape coefficient (scx value).
  - The size and weight of any additional attachments.
4. Columns and brackets shall be structurally designed to be capable of accepting lanterns with the following minimum weight and windage:

5m post top	9.0kg	0.08m <sup>2</sup>
6m post top	9.0kg	0.08m <sup>2</sup>
8m post top	15.0kg	0.13m <sup>2</sup>
10m post top	15.0kg	0.13m <sup>2</sup>
12m post top	15.0kg	0.13m <sup>2</sup>
5m side entry (0.5m projection)	9.0kg	0.08m <sup>2</sup>
6m side entry (0.5m projection)	9.0kg	0.08m <sup>2</sup>
8m side entry (1.0m projection)	15.0kg	0.13m <sup>2</sup>
10m side entry (1.5m projection)	15.0kg	0.13m <sup>2</sup>
12m side entry (1.5m projection)	15.0kg	0.13m <sup>2</sup>

5m mid-hinged raise & lower	9.0kg	0.08m <sup>2</sup>
6m mid-hinged raise & lower	9.0kg	0.08m <sup>2</sup>
8m mid-hinged raise & lower	15.0kg	0.13m <sup>2</sup>
10m mid-hinged raise & lower	15.0kg	0.13m <sup>2</sup>

5. The lighting column planting depth shall be in accordance with manufacturers' recommendations and PD 6547: +A12009.
6. The design shall include for a sign loading of 0.3m<sup>2</sup> x 1.8 shape coefficients for 5m & 6m columns and 1.0m<sup>2</sup> for 8, 10 & 12m columns.
7. 5, 8, 10 & 12 metre columns shall be designed to carry the following additional loads but shall not carry any of the sign loading listed above in note 3.
  - a) Twin Hanging Baskets with a wet soil weight of 20kg for each single basket mounted at 2.5m above ground level.  
or
  - b) Single Banner loaded on spring mounted banner arms 2.032m high x 0.762m mounted 2.1 metres from ground level to bottom of banner.  
or
  - c) Christmas Decoration 1.5m<sup>2</sup>x 30% solid weighing 20kg mounted 2.100 from ground level to bottom of decoration.
8. The root protection shall have a minimum of G1 or two pack high build epoxy (see ILP TR26) coating both inside and out of the planted section and finish 250mm above ground level. A minimum of 250 microns dry film finish shall be attained.
9. The lighting column base compartment section shall be a minimum of 1400mm from ground level to the top of the door aperture for 5 and 6m columns or 1000mm to the base of the door for 8 to 15m columns. The opening shall have a minimum clear opening of 600mm x 115mm for 8, 10 & 12m columns.
10. The base compartment shall incorporate a Non-Hygroscopic treated hardwood backboard with screwed fixings both top and bottom.
11. Where there is a need to use a twin bracket arm with an apposing gear in head luminaire arrangement then the column may be designed using a single door only. Design data shall be submitted for approval prior to installation.

## Hinged columns

12. Base hinged columns shall contain a built in hinge mechanism that raises the upper base and shaft section vertically clear of the lower base section. When the column is lowered it shall be operated by way of a compression spring device. When the column is in the upright position it will be secured with a tamper proof M8 bolt.
13. For hinged columns, a door shall be provided and shall be a minimum of 600mm above ground level and have an earth terminal affixed to the base and the door. A captive length of flexible conduit should protect the internal wiring cables from accidental pinching between the column base and shaft sections.
14. Mid-hinged columns up to 6 metres mounting height shall be equipped with a lowering rope or some form of descent controlling device.
15. Hinged columns of 8 metres to 12 metres mounting height shall be equipped with a lowering jack and be complete with a door with an earth terminal.
16. Lighting column cable entry slot shall be 75mm in width and 150mm in height.
17. Each column and bracket shall carry a unique permanent identification mark to show the manufacturer and year of production as a minimum and bracket data sheet reference number. The manufacture process shall be in accordance with Annex-A of BSEN 40.
18. Eight stainless steel M8 grub screws shall be used to secure the bracket in place and act as an alignment facility.
19. Bracket arms shall have a minimum rise of two degrees for use with a flat glass and LED luminaires and a maximum of five degrees for curved tempered glass luminaires. The bracket shall be designed in such a way so as to compensate for a flat glass lantern coming to rest as close to zero degrees as is practicable.
20. The bracket arm tube shall be the same diameter along its length and shall be a minimum of 42.4mm. Where the outside diameter exceeds 60mm a step reduction for the lantern spigot will be engineered accordingly. All brackets shall incorporate an anti-rotation device.
21. For hinged columns up to 6 metre mounting height, there is a requirement for a door and shall be a minimum of 400mm above ground level and have an earth terminal.
22. A captive length of flexible conduit should protect the internal wiring cables from accidental pinching between the column base and shaft sections or the hinged section.
23. Nothing shall be attached to hinged columns,
24. Mid hinged columns shall have a removable hinge pin to allow separation of the upper and lower sections to aid manual handling. The removable pin shall be held securely in place by a retaining device.

## HMEP CL 1304 SR - IDENTIFICATION AND LOCATION MARKINGS

1. All lighting columns and brackets shall carry a unique identification label or stamp stating the name of the manufacturer, year of manufacture and the manufacturer's product code.
2. Have a permanent fixed label on the column and hard stamped on the bracket.
3. The bracket identification mark shall be permanent and legible and be:
  - (i) hard stamped; or
  - (ii) formed in the material of the bracket on an external face only.
  - (iii) The mark shall be located either on the luminaire spigot or on the underside of the bracket adjacent to the column shaft or wall or pole mounting plate.
4. In addition, location marks for inspection and maintenance purposes shall be applied to each column as described in Appendices 13/1, 13/4 and 13/7.

## HMEP CL 1308 SR – HANDLING, TRANSPORT AND ERECTION

1. Lighting columns and brackets, CCTV masts and cantilever masts shall be handled, transported and stored in such a way as to avoid any structural damage or damage to the surface protection system. Any damage incurred shall be made good in such a way that the structural performance and durability of the item shall be in no way reduced.
2. Lighting columns and brackets, CCTV masts and cantilever masts shall be stored clear of the ground in such a way that contact with cement, groundwater, soil or ash or other deleterious material is prevented and that water does not accumulate on any surfaces or inside sections. Suitable packings shall be placed between the columns/masts to allow a free passage of air and dispersion of water.
3. All rivets, bolts, nuts, washers, screws, small plates and small articles generally shall be suitably packed and identified. All such items shall be stored under cover.
4. Columns and masts shall be installed in accordance with the manufacturer's recommendations. The door shall face the direction described in Appendices 13/1, 13/4 and 13/7.
5. All works shall be carried out in accordance with the manufacturers instructions and recommendations unless instructed otherwise by the Overseeing Organisation.
6. All lighting columns shall be packed at contact points for transport and storage to protect the finish.
7. Where hinge columns are to be manually handled during maintenance the total weight of the column shall be considered. All lighting columns erected in areas with difficult accessibility as defined by the Overseeing Organisation shall be folded steel type and

mid hinged. The column shall be split into two parts by removing the hinge pin and the procedure will follow the manual handling assessment.

8. Base Hinged Columns shall be lowered using a spring loaded counterbalance unit for columns up to 6 metre mounting height and a hydraulically powered unit over 6 metre mounting height.
9. Mid Hinged Columns shall be lowered using an appropriate system provided or approved by the manufacturer.

### Notes for guidance series 1300 HMEP

#### General

This document is intended to harmonise with the specification for Highway Works and adoption of the notes for guidance harmonises with the ADEPT document issued in September 2010 and coordinates with the Lighting Column Manufacturers Association and BS EN40 including PD 6547.

The premise is to allow the specifier/buyer of a local Highway Authority to buy in bulk a unified product.

It is important to separate the employer's requirements into two sections. These items being: "In Scope" and "Out of Scope".

There is always the opportunity to provide equipment for special cases such as high vandal areas and town centres and passive safety. This document is meant for the majority of normal circumstances and concentrates on the standard root planted single stepped tubular steel column.

#### EN40 – 25 year design life

1. The HMEP design allows for a sacrificial steel element thickness of 4mm which extend the term life of the column and beyond. It also gives long term savings as apposed to short term.
2. The provision of a root protection gives long term durability within varied soil conditions. High pollution areas can be varied and indiscriminate. The choice of a root protection coating has been kept to its simplest and most effective to maintain good protection and value for money.
3. BS EN 40 only requires the column design to represent a structural performance attaining a 25 year life. However, this can be extended by providing at least a good root protection and as an extra measure the column can have a shop applied exterior coating that potentially will provide a 50 year life.

### **Ergonomics and Health and Safety**

1. The door position has been raised to give the maintainer /installer ease of posture i.e. sitting or standing to work. This has been adopted from best practice and feedback within the industry.
2. Fewer visits to a lighting column should improve the owner's carbon footprint. The manufacture of products, product life cycle and installation considerations should support sustainability.
3. By covering the galvanised coating this stops erosion of its properties and in turn stops waste metals being deposited into the soil and water courses.
4. The affixation of identification numbers shall be positioned on the column shaft at a height above ground level of 1500mm to negate the use of any platform or step ladders. The number is placed at 90 degrees to the kerb edge for single and dual carriageways to allow it to be viewed from both directions of travel and the opposite carriageway.
5. Removal hinge pin has been suggested for a mid hinge column to allow the separation of the upper and lower sections for lighting columns of 5 & 6 m only. It is anticipated this will aid the manual handling process.

### **Best Practice**

1. The decision to retain a bracket facility is in line with the requirements of LED luminaires being mostly side entry mounting.
2. All attachments and securing screws are stainless steel including the earth stud and door lock.
3. The door securing screw is also stainless steel in accordance with EN40 and tri-headed in line with preferred method. This also allows convenience of purchase from a local supplier, which in turn reduces cost. The total mounting height of the column has been set to allow a single unit to be purchased that fits two applications, Post Top and Side Entry. This streamlines stock holding and simplifies the contractors selection when loading equipment prior to commencing work i.e. he doesn't have to be concerned about loading a 5m post or side entry column as it is the same length.  
The decision to use a 76.10mm spigot top falls into line with modern luminaire facilities of the day.
4. The decision to retain a bracket facility is in line with the requirements of LED luminaires being mostly side entry mounting.
5. All attachments and securing screws are stainless steel including the earth stud and door lock.
6. The door securing screw is also stainless steel in accordance with EN40 and tri-headed in line with preferred method. This also allows convenience of purchase from a local supplier, which in turn reduces cost.

## SERIES 1700 – STRUCTURAL CONCRETE

Following review of the information provided by the contributing local authorities it became apparent that alterations to the Manual of Contract Documents for Highways Works and Specification for Highways Works for structural concrete were limited. It was assumed that where structural concrete is specified it is normally as part of an individual project relating to a single structure, and is designed, specified and detailed to comply with current standards applicable at that time. Its use in the replacement or repair of structures is not a common occurrence for local highway authorities. This assumption was mirrored in the review of the information provided by local highways authorities, where no indication of the use of structural concrete was found.

Most local authority works are associated with the routine inspection and maintenance of concrete structures, and not with the replacement or renewal of the structure itself. As a result the focus of this section of the brief was altered to develop specification clauses for the repair and maintenance of structural concrete.

The table below lists the current Clauses from the Specification for Highways Works and alternate Clauses developed by the HMEP for local highways authority use for the repair of concrete structures.

Series 1700 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
1701	(05/04) Concrete - General 2	-	-
1702	(05/04) Concrete - Constituent Materials 2	-	-
1703	(05/04) Concrete - Exposure Classes 2	-	-
1704	Concrete - General Requirements 3	-	-
1705	(05/04) Concrete - Requirements for Designed Concrete 3	-	-
1706	Concrete - Production 4	-	-
1707	(05/04) Concrete - Conformity and Identity Testing 4	-	-
1708	Concrete - Surface Finish 4	-	-

Table Continued			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
1709	(05/01) Concrete - Surface Impregnation 6	-	-
1710	Concrete - Construction General 8	-	-
1711	(05/01) Concrete - Grouting and Duct Systems For Post-tensioned Tendons 12	-	-
1712	(05/01) Reinforcement - Materials 17	-	-
1713	(05/02) Carbon Steel Reinforcement and Stainless Steel Reinforcement - Bar Schedule Dimensions - Cutting and Bending 18	-	-
1714	Reinforcement - Fixing 18	-	-
1715	Reinforcement - Surface Condition 18	-	-
1716	(05/01) Reinforcement - Laps and Joints 18	-	-
1717	Reinforcement - Welding 19	-	-
1718	Prestressing Tendons - Materials 19	-	-
1719	Prestressing Tendons - Handling and Storage 19	-	-
1720	Prestressing Tendons - Surface Condition 20	-	-
1721	Prestressing Tendons - Straightness 20	-	-
1722	Prestressing Tendons - Cutting 20	-	-
1723	Prestressing Tendons - Positioning of Tendons, Sheaths and Duct Formers 20	-	-

<b>Table Continued</b>			
1724	Prestressing Tendons - Tensioning 20	-	-
1725	Prestressing Tendons - Protection and Bond 22	-	-
1726	Stainless Steel Dowels - Materials 22	-	-
1727	Inspection and Testing of Structures and Components 22	-	-
-	-	1728AR	Concrete repairs - General
-	-	1729AR	Concrete repair - preparation of substrate
-	-	1730AR	Concrete Injection
-	-	1731AR	Structural and non-structural repair
-	-	1732AR	Structural bonding
-	-	1733AR	Quality control

## HMEP CL.1728AR CONCRETE REPAIRS – GENERAL

### Assessment of condition

1. Prior to commencing repairs to concrete, an assessment of the condition of the structure to BS EN 1504-9 shall have been completed.

### Selection of repair principle

2. The appropriate repair principle or principles defined in BS EN 1504-9 shall be selected.

### Selection of repair products

3. The products and systems to be used shall be selected in accordance with the requirements of BS EN 1504 parts 2 to 7, or other relevant European Standard or appropriate European Technical Approvals. Care shall be taken that products and systems do not undergo adverse physical or chemical reactions with each other and with the concrete structures.

### Storage of Materials

4. Cement and aggregates shall be stored in accordance with Clause 1706. All proprietary materials shall be stored in a dry weatherproof lock up store free from extremes of cold or heat in accordance with the manufacturer's instructions.
5. The materials shall not be removed from the store for use in the works until immediately prior to mixing.
6. Material shall not be older than 3 months or such lesser period specified by the supplier when incorporated in the works. The date of manufacture shall be marked on the container.

## HMEP NG 1728AR CONCRETE REPAIRS – GENERAL

### Assessment of condition

1. Any planned repairs should form part of a management strategy for the structure. The causes of any defects should have been identified and the condition of the concrete and reinforcement established. Any repair scheme should consider the structural, health and safety and environmental implications of the proposed methods and products.

### Selection of repair principle

2. When, having considered the management strategy for the structure, condition of the structure, cause of defects and results of any tests, it has been deemed necessary to carry out repairs, the appropriate BS EN 1504 design principles should

be selected:

- a. Protection against ingress.
- b. Moisture control.
- c. Concrete restoration.
- d. Structural strengthening.
- e. Increasing physical resistance.
- f. Resistance to chemicals.
- g. Preserving or restoring passivity.
- h. Increasing resistivity.
- i. Cathodic control.
- j. Cathodic protection.
- k. Control of anodic areas.

#### **Storage of Materials**

3. All materials vulnerable to deterioration should be protected from the weather prior to use.
4. Proprietary repair products should be stored in accordance with the manufacturer's recommendations.

## **HMEP CL.1729AR CONCRETE REPAIR – PREPARATION OF SUBSTRATE**

### **Access to Repair Areas for Inspection**

1. The Contractor shall allow the Overseeing Organisation a minimum period of 3 hours of unhindered access to each area before work commences. This is to allow him time to inspect and test the concrete to identify repair areas. The Contractor shall notify the Overseeing Organisation at least 24 hours before inspection is required.

As repair work proceeds, the Overseeing Organisation will continue to carry out inspections and may undertake further testing to establish the limits of the concrete to be removed.

2. The Contractor shall allow in his programme for these periods of inspection and testing.

### **High Pressure Water Jetting**

3. If water for the Works is not available from a Public Utility Undertaking supply, the Overseeing Organisation's approval shall be obtained regarding the source of supply and manner of its use. When required by the Overseeing Organisation the Contractor shall arrange for tests of the water to be carried out in accordance with BS EN 1008. Water from the sea or tidal rivers shall not be used.

### Removal of concrete

4. Weak, damaged or deteriorated concrete shall be removed prior to the application of repair products.
5. Existing concrete shall be removed to the extent instructed by the Overseeing Organisation. Removal of concrete additional to that described in the Contract may be instructed by the Overseeing Organisation if found to be necessary.
6. Concrete shall be removed from the area until sound concrete is reached. Where reinforcement becomes exposed, concrete shall be removed for a minimum distance of 25mm beyond the rear face of the reinforcement. Where corroded reinforcement is identified the area of concrete removed shall be extended to expose 100mm of uncorroded reinforcement.
7. Before cutting out, the Contractor shall determine the position and depth of the reinforcement with a covermeter. The perimeter of the concrete to be removed shall, except as described below, be saw cut perpendicularly to the face of the concrete to a depth of not less than 15mm or to within 10mm of the reinforcement, whichever is the lesser.
8. The edges of repair areas shall be inclined to avoid the entrapment of air when the concrete is poured.
9. Concrete shall be removed by the use of suitable light hand held mechanical tools or high pressure water jetting in accordance.
10. Any saw-cut edges produced shall be abraded by grit blasting or equivalent method. The surface of the concrete to receive repair concrete is to be such that the repair concrete will flow freely into all voids and be in intimate contact with the existing concrete.
11. The Contractor shall not damage concrete to be retained adjacent to, above or below repair and replacement areas. Any concrete damaged by the Contractor shall be rectified as directed by the Overseeing Organisation. The Contractor shall not damage the steel reinforcement. Any steel reinforcement damaged by the Contractor shall be rectified as directed by the Overseeing Organisation.
12. The profile of each area, after removal of the existing concrete, shall be as detailed on the Contract Drawings or as directed by the Overseeing Organisation for each area within a  $\pm 5$ mm tolerance.

### Preparation of surface of concrete

13. Concrete surfaces shall be clean and dry and free of cement laitance, contaminants and loose friable material.

14. The surface of the concrete shall be cleaned of all dust and abrasive particles. Filtered oil-free air, or a similar accepted method, shall be used to remove any loose particles.
15. The surfaces shall then be saturated with potable water for a minimum of 4 hours and repair material shall be placed within one hour after completion of wetting.
16. Bonding agents shall not be used between the substrate and the repair concrete unless required by manufacturer of proprietary repair product and approved by the Overseeing Organisation.

#### **Preparation of surface of reinforcement**

17. Exposed surfaces of reinforcement shall be cleaned to bright steel. The surfaces shall be free of embedded abrasive particles and corrosion products when viewed through a x10 illuminated magnifying glass.

Method :

Blast cleaning using dry air/abrasive system;

or

Wet blast cleaning using a low pressure air/water/abrasive system. The equipment shall not allow the air/water pressure to exceed 14 bar and shall incorporate a metering device to allow the abrasive quantity introduced to be adjusted from zero to a maximum.

18. Within an hour of blast cleaning the treated reinforcement shall be pressure washed with clean water.
19. In locations where more than 10% of the cross sectional area of the bar has been lost the advice of the Overseeing Organisation must be sought before proceeding.

### **HMEP NG 1729 CONCRETE REPAIR – PREPARATION OF SUBSTRATE**

#### **Access to Repair Areas for Inspection**

1. The nature of repair work means that the extent of the work required may vary as access to areas is provided and the extent of damage can be more accurately assessed.

#### **Removal of concrete**

2. Structural considerations may limit the extent of the removal of concrete

**Preparation of surface of concrete**

3. The surface of the concrete prior to the application of repair products shall be such that the material will flow freely into all voids and be in intimate contact with the existing concrete.
4. A compressor is not to be used for blowing clean unless it can be shown that there is no possibility of contamination from oil mist.

**Preparation of surface of reinforcement**

5. All exposed reinforcement shall be prepared by abrasive blast cleaning to achieve a bright metal finish taking care that this standard is achieved for the full circumference on round bars and to the satisfaction of the Overseeing Organisation on flat bars.

**HMEP CL. 1730AR CONCRETE INJECTION****General**

1. Products used for the injection of cracks shall conform to the requirements of BS EN 1504-5 and appendix 17/8

**Surface preparation**

2. The general requirements in clause 1729AR shall be met except as modified below.
3. The concrete surface at least 50mm either side of the crack shall be dry blast cleaned to a sound surface free from dirt, moss, salt staining and loose concrete. The full extent of the crack shall be found and the cleaned area shall extend 50mm beyond the end of the crack or until, in the opinion of the Overseeing Organisation, the crack becomes too narrow to warrant resin injection.
4. Where algae or other bacterial growth emanates from the crack it shall be removed by scrubbing with bactericide and rinsing with clean water. Health and safety precautions appropriate to the bactericide cleaning agent used shall be adopted, including those recommended by the manufacturers. The Contractor shall also take all measures necessary to ensure that any adjacent water course is not contaminated, and that run-off is collected and disposed of in a safe manner.

**Moisture in Cracks**

5. Where, in the opinion of the Overseeing Organisation, the moisture level in the crack to be resin injected is unacceptably high the crack shall be blown through with dry hot air starting at the top of the crack. The temporary crack sealant shall be applied

immediately after blowing through and the resin shall be injected into the crack immediately the necessary preparations are complete.

6. If, for whatever reason, the crack becomes damp before it is resin injected, no further work will be permitted until the temporary crack sealant is removed and the crack blown through again with dry hot air.
7. The temperature of the hot air shall be, in the opinion of the Overseeing Organisation, sufficient to dry the full depth of the crack and shall not exceed the maximum temperature specified by the equipment manufacturer.

### **Resin Injection**

8. The resin to be used shall be either polyester or epoxy based and shall be mixed and injected in accordance with the manufacturer's Specification. Resin shall not be injected when ambient temperature, or the temperature of the concrete to be repaired, is less than 5°C.
9. The spacing of the nozzle positions shall be equal to the depth of the crack and agreed with the Overseeing Organisation, and shall not in any case be less than 250mm.
10. Injecting shall start at the bottom of the crack and work shall proceed upwards in a continuous operation throughout. Resin must be seen extruding from the next higher nozzle position before the current nozzle is locked off.
11. The injected crack shall be left undisturbed for a period of at least 24 hours to allow the resin to harden.
12. When the resins are sufficiently cured the injection nozzles shall be removed and temporary crack sealant and resin spillages removed from the face of the concrete by flexible abrasive discs or other means accepted by the Overseeing Organisation.

### **Proving Tests**

13. When the resin has set two 20mm diameter proving cores shall be taken to the full depth of the crack. The core holes shall be filled with the resin used for injecting or with an accepted filler of a compactable thixotropic resin or with Repair Mortar as specified in Clause 1731.16AR. The location of the cores shall be fixed on site by the Overseeing Organisation.

### **Application of Sealer**

14. The sealing resin shall be a low viscosity polyester, epoxy or acrylic polymer. For bridge decks the resin shall be compatible with any proposed waterproofing system.
15. The material shall be applied by pouring through a fine nozzle directly into the crack or into preformed dams.
16. The injected crack shall be left undisturbed for a period of at least 24 hours to allow the resin to harden.

17. When the resins are sufficiently cured the preformed dams, resin and resin spillages shall be removed from the face of the concrete by flexible abrasive discs or other means accepted by the Overseeing Organisation.

## HMEP NG 1730AR CONCRETE INJECTION

### General

1. Concrete injection is used as a method for the following principles defined in EN1504-9:

- Principle 1: Protection against ingress and waterproofing; Filling cracks (method 1.4).
- Principle 4: Structural strengthening; Injecting cracks, voids or interstices (method 4.5). Filling cracks, voids or interstices (method 4.6).

2. Injection is used to avoid the harmful consequences of voids and cracks in concrete to:

- Achieve impermeability and hence watertightness;
- Avoid penetration of aggressive agents that might induce corrosion of steel reinforcement;
- Strengthen the structure by strengthening the concrete.

3. EN 1504-5 covers the injection of cracks, voids and interstices in concrete using three generic material types:

- Those capable of transmitting forces (F), generally cement-based materials, epoxies and polyesters
- Those capable of remaining ductile (D), i.e. flexible to accommodate future movement - generally polyurethanes
- Those capable of swelling to fill the crack (S); these are generally polyurethanes and acrylics.

## HMEP CL. 1731 STRUCTURAL AND NON-STRUCTURAL REPAIR

### General

1. Structural and non-structural repair to defective concrete is carried out using either hand-applied patch repairs, or recasting with flowing concrete or mortar, or applying

concrete or mortar by spraying. Repairs shall conform to the requirements of BS EN 1504-3

### Materials

2. Pre-batched, shrinkage compensated, acrylic polymer modified cementitious products shall be used.
3. Properties of the repair product shall comply with the requirements of BS EN 1594-3 and appendix 17/8.
4. The proprietary materials shall be supplied by a manufacturer who holds a BSI certificate to BS EN ISO 9000 or operates an equivalent quality assurance system.
5. The Contractor shall supply with each batch of the material delivered to Site, certificates furnished by the supplier stating compliance with BS EN1504-3 and the relevant class.
6. Concrete constituents for repair products shall comply with the requirements of clauses 1702 and 1704.
7. The maximum aggregate size in the mortar shall be selected to be suitable for the depths of repair required and accepted by the Overseeing Organisation.
8. Silica fume used in proprietary products shall comply with the requirements of BS EN 13263-1 class 1 and shall not exceed 5% of the mass of the cement.
9. Water required to mix repair products shall comply with BS EN 1008.

### Application – general

10. The repair product shall be suitable for the purpose intended e.g. for soffits or vertical surfaces as appropriate.
11. Repairs shall be built up in layers in accordance with the repair material manufacturer's instructions. The surface of each layer, except the final layer shall be scored to provide a key for the next layer.
12. Repair product shall not be applied when ambient temperatures or the temperature of the surface to be repaired is below 5°C.
13. The repair product when placed shall have a temperature of not less than 5°C and not more than 20°C.
14. The material shall be incorporated in the works within 1 hour of mixing or such lesser period as stated by the manufacturer.
15. Repair products shall be cured in accordance with Clause 1710.5 and the repair mortar manufacturers instructions. During the curing period the temperatures of the repair products shall be maintained at or above 5°C, by artificial means if necessary.

**Applying Mortar by Hand**

16. Pre-batched, shrinkage-compensated polymer-modified cementitious mortars with appropriate bond coats, primers or slurry coats as recommended by the manufacturer shall be used.
17. Repair mortar shall be float finished to produce a dense, smooth uniform surface free from float marks, and to the specified line and level.

**Recasting with Concrete or Mortar**

18. Proprietary material shall be of such composition and grading that when mixed with water a flowable concrete is produced which will flow freely into the confined spaces to be filled and shall not be prone to segregation, bleeding or cracking in either the plastic or hardened state.
19. Formwork as described in Clause 1710.2 shall be capable of producing a Class F3 surface finish to Clause 1708.4 with the perimeter of the repair well sealed to prevent grout loss. Release agents shall be compatible with proposed surface treatments. Concrete surfaces and reinforcement shall not be contaminated with release agent.
20. Mixing in an accepted forced action paddle mixer and placing shall be carried out strictly in accordance with the formulator's written instructions together with the following additional conditions.
21. The water content shall be determined during Approval Tests, accepted by the Overseeing Organisation and maintained for Batch Tests, works Tests and in the Works within + 2% of the agreed content.
22. No extra water shall be added after the original mixing.
23. The material shall be incorporated in the works within 20 minutes of completion of mixing, or such lesser period as stated by the formulator. The concrete shall be continuously agitated after the mixing and before placing.
24. The surface temperature of the concrete shall be maintained at not less than 5°C until the concrete reaches a strength of 10 N/mm<sup>2</sup> as determined by tests on cubes cured under similar conditions to the structural concrete in a manner accepted by the Overseeing Organisation. Heat shall not be applied directly to any concrete
25. Repair concrete shall not be placed against other concrete which has been in position for more than 30 minutes unless a construction joint is formed in accordance with Clause 1710 of the Specification. In addition the joint surface shall be saturated for a minimum of 2 hours before concrete is placed against it. When repair concrete has been in place for 4 hours, or less as directed by the Overseeing Organisation, no further concrete shall be placed against it for a further 20 hours.
26. Vibration shall not be used. The side shutters shall be tapped lightly with a hammer to expel surface air voids.

27. Immediately after placing and for 14 days thereafter, concrete shall be protected against harmful effects of weather including rain, rapid temperature changes, frost and from drying out. The methods of protection used shall in all cases be subject to the acceptance of the Overseeing Organisation. Proprietary curing membranes shall not be used.
28. When the mix proportions have been accepted by the Overseeing Organisation no variations shall be made in the manufacture, supply, mix proportions or method of mixing of the material without the written consent of the Overseeing Organisation.

### **Spraying Mortar or Concrete**

29. The proprietary material shall be pre-weighed and pre-mixed at an address accepted by the Overseeing Organisation. Such acceptance will require demonstration that adequate quality control will be maintained at all times.
30. Material shall be capable of being applied to a thickness of 100mm without the requirement for additional mesh reinforcement or fibres. Once placed it shall be capable of being profiled and trowel finished (to the equivalent of formed F2) without detrimental effects.
31. Where required fibres shall be 25mm long stainless steel conforming to BS EN 14889-1 Group III.
32. When required by the Overseeing Organisation, procedure trials shall be used to demonstrate the suitability of the proposed mix, the method of working and the competence of the operators.
  - a) Spraying shall be interrupted at each layer of reinforcement and the compaction of the deposited concrete or mortar checked.
  - b) Where required by the Overseeing Organisation the Contractor shall cut 100mm diameter cores to determine the quality of the deposited concrete or mortar.
  - c) Any variations in the mix proportions, in the method of working or change in the operators shall require further procedure trials to the Overseeing Organisation's satisfaction.
33. A method statement shall be submitted to the Overseeing Organisation for approval prior to commencing spraying and shall cover:
  - a) Outline definition
  - b) Mixing of material
  - c) Installation of reinforcement (if appropriate)
  - d) Transport and placing

- e) Construction joints
- f) Curing

34. Panels shall be prepared for approval testing. A minimum of two test panels for each position in the works (e.g. Vertical horizontal, overhead, inclined) shall be produced by each of the proposed “nozzle men”. The test panels shall be sprayed using the materials and equipment proposed for use in the works. The panels shall be produced in moulds accepted by the Overseeing Organisation 750 x 750 x 100mm minimum size, suitable for quartering and coring.
35. The quartered panels shall be stored and cores tested in accordance with BS EN 12504-1:2000. Suitable identification marks shall be applied and the Contractor shall maintain records of panel and core identities.
36. Four number 100mm diameter cores shall be taken through the depth of the panel from each quarter panel at least 48 hours after the panel has been sprayed. One core shall be compression tested at 3 days, one at 7 days and the remaining two at 28 days. The coring, core testing and capping shall be carried out in accordance with BS EN 12504-1:2000 at a laboratory accepted by the Overseeing Organisation.
37. The appropriate compressive strength requirement for each set of two 28 day cores shall be satisfied if each of the two cores gives an equivalent 150mm cube strength at least that specified and the difference between the greatest and least strengths shall not be more than 20% of the average. The cores shall be examined for voids or laminations and they shall not reveal voids or laminations. The Overseeing Organisation may require the remainder of the panel to be broken and the broken surfaces shall not reveal voids or laminations.
38. Where fibre reinforced sprayed concrete is used, the weight of fibres shall not exceed 5% by weight of the combined weight of cement and aggregate. Fibres shall be added to the mix in such a manner that the fibres are evenly distributed. Procedure trials shall be undertaken to demonstrate that the proposed methods can achieve the requirements of this sub-Clause.
39. Unless otherwise agreed, a final 15mm thick coat of unreinforced sprayed concrete shall be applied over the whole exposed surface to cover exposed fibres.

## HMEP NG 1731 STRUCTURAL AND NON-STRUCTURAL REPAIR

### General

1. Structural and non-structural repair covers repairs with mortars and concretes, possibly used in conjunction with other products and systems, to restore and/or to replace defective concrete and to protect reinforcement, necessary to extend the service life of a concrete structure exhibiting deterioration. The fields of application covered are in accordance with BS EN 1504-9 as follows:
  - a. Principle 3 - Concrete restoration
    - Method 3.1 Applying mortar by hand
    - Method 3.2 Recasting with concrete
    - Method 3.3 Spraying mortar or concrete
  - b. Principle 4 - Structural strengthening
    - Method 4.4 Adding mortar or concrete
  - c. Principle 7 - Preserving or restoring passivity
    - Method 7.1 Increasing cover to reinforcement with mortar or concrete
    - Method 7.2 Replacing contaminated concrete
2. Repair mortar should generally be used where repairs are less than one square metre in area, or repair depth is less than 30mm, or as otherwise instructed by the Overseeing Organisation.
3. Proprietary high-flow repair concrete should generally be used for repairs greater than one square meter in area and repair depth greater than 30mm or as otherwise instructed by the Overseeing Organisation.

### Materials

4. Repair products should have similar properties to the original concrete and be either class R3 or R4 for structural repairs and class R1 or R2 for non-structural as defined in BS EN 1504-3.
5. If water for the Works is not available from a Public Utility Undertaking supply, the Overseeing Organisation's approval shall be obtained regarding the source of supply and manner of its use. When required by the Overseeing Organisation the

Contractor shall arrange for tests of the water to be carried out in accordance with BS EN 1008. Water from the sea or tidal rivers shall not be used.

#### **Recasting with concrete or mortar**

6. All formwork, where required, should have an inlet system incorporated into the shutter to allow the concrete to be introduced via an external pipe, either pumped or poured with a suitable head.

#### **Spraying mortar or concrete**

7. A detailed method statement shall be submitted to the Overseeing Organisation for approval. The following paragraphs offer an acceptable approach but are not exhaustive.
8. The outline of the finished sprayed concrete shall be defined by screed boards, guide wires or other means accepted by the Overseeing Organisation.
9. Guide wires shall be installed tight and true to line and in such a manner that they may be easily tightened.
10. Sprayed concrete shall be mixed in a batch type mixer complying with the requirements of BS 1305 except that the water shall be delivered direct to the nozzle. The delivery equipment shall be capable of delivering a continuous even stream of uniformly mixed material to the nozzle. Water supply at the nozzle shall be maintained at a uniform pressure sufficient to ensure adequate hydration at all times. The delivery equipment and nozzle shall be thoroughly cleaned and inspected at the end of each day and parts replaced as required.
11. The temperature of water and cement when added to the mix shall not exceed 60°C and 65°C respectively.
12. Where shown on the Service or Scheme Instruction reinforcement fixed to prepared surfaces shall consist of 50mm x 50mm x 2.36 kg/m<sup>2</sup> welded steel fabric. It shall be carefully bent to follow the shape of the members, and held in position using concrete anchors spaced at not less than two per square metre. The fabric shall be spaced at not less than 25mm from the surface of the existing concrete. Mesh should be lapped one and one half squares and reinforcement shall be staggered and spaced to allow complete encasement by the concrete. A minimum finished cover of 40mm shall be provided to the steel reinforcing fabric, unless agreed otherwise.
13. Sprayed concrete shall emerge from the nozzle in a steady uninterrupted flow and an uninterrupted supply of compressed air shall be provided to maintain adequate nozzle velocity. Should the flow become intermittent the nozzle shall be directed away from the work until the flow again becomes uniform.
14. Sprayed concrete shall be applied under sufficient pressure so as to give a dense and homogeneous covering to the surface in one or more layers of a thickness

- compatible with the mix design, constituents, position of reinforcement, and plane of application to ensure the placed concrete does not slump or sag.
15. Adequate precautions shall be taken to ensure that sprayed concrete rebound is not incorporated in the finished work and that any previously deposited hardened rebound which may prevent a proper bond or encasement is removed from reinforcement.
  16. Adequate protection shall be given to the nozzle and application surface during high winds.
  17. Finishing of the surface of the final coat shall be carried out as soon as practicable after spray application. A Class U3 finish shall be achieved in accordance with Clause 1708.4.
  18. The nozzleman shall hold a current certificate of competence in spray concrete, issued by the Sprayed Concrete Association.
  19. The gun and nozzle shall be electrically earthed.
  20. Construction joints in sprayed concrete shall be tapered at approximately 30 degrees from a plane perpendicular to the finished surface or cut back square to the reinforcement and then tapered at 30 degrees, unless otherwise specified by the Overseeing Organisation. The construction joint shall be thoroughly cleaned, all laitance and loose material removed and the surface wetted using a strong blast of air and water, prior to the placement of the adjacent sprayed concrete.
  21. Freshly sprayed concrete shall be protected from rain or water until the surface is sufficiently hard to resist damage.
  22. Immediately after placing and for 14 days thereafter sprayed concrete shall be protected against harmful effects of weather including rain, rapid temperature changes, frost and from drying out. The methods of protection shall in all cases be subject to the acceptance of the Overseeing Organisation. Curing membranes shall not be used.
  23. Alternatively subject to the acceptance of the Overseeing Organisation impregnation in accordance with Clause 1709 may be carried out after 14 days.

## HMEP CL. 1732AR STRUCTURAL BONDING

### General

1. Steel plate shall comply with BS EN 10025 Fe 430.
2. Any repairs required to concrete shall comply with relevant points of series 1700 of the Specification including additional clauses. All areas of repair to Structural Concrete will have attained full 28 day specified strength before plates may be adhered to the surface.

### Bonding agent

3. Bonding agents shall comply with the appropriate requirements of EN 1504-4 and appendix 17/8.

### Lap Shear Strength

4. Tests shall be carried out over a range of temperatures specifically including - 25°C, + 20°C and + 45°C using bright mild steel adherents. The temperatures shall be measured by means of thermocouples attached to the steel surface of the joint using a double overlap joint as shown below. The minimum average lap shear stress shall be 8 N/mm<sup>2</sup> at 20°C. The ends of the main test pieces shall be debonded to avoid load being transferred in tension, and any adhesive spew at the ends of the side laps shall be carefully removed. Testing procedure as given in BS5350 Part C5 (ref 13) shall be used.

### Placing

5. The adhesive shall be capable of being applied readily to both concrete and steel surfaces in layers from 2-10mm thick.

### Cure Time and Temperature

6. The adhesive shall be capable of curing to the required strength between 10°C and 30°C in relative humidity of up to 95%. For repairs and strengthening works the adhesive shall cure sufficient to give the specified mechanical properties at 20°C in not more than three days. On curing the adhesive shall undergo negligible shrinkage.

### Preparation and application

7. The concrete surface of an existing member shall be prepared for bonding by grit blasting or other approved method of removing weak materials, laitance and surface contamination. Cracks wider than 0.2mm which could allow loss of adhesive and areas of concrete that appear porous should be sealed with a compatible resin. The prepared surface should be dust free and surface dry.
8. The surface of the steel to be bonded must be completely free of any mill-scale, rust, grease or other contaminants. All surface dust on the plates shall be removed by

vacuuming immediately before application of the primer. The primer, for the epoxy resin adhesive, shall be an epoxy based system which is compatible with the adhesive. It shall be applied to the surfaces to be bonded at a dry film thickness not exceeding 50 microns within four hours of grit blasting and allowed to cure for the time specified by the manufacturer at the appropriate temperature. The primer for the alternative adhesive should be compatible with the adhesive and should be applied in accordance with the manufacturer's instruction. Subsequent handling should be undertaken by operatives wearing clean gloves. The plates should be wrapped in clean protection material in the presence of a desiccant and stored in clean dry conditions. Before the application of the adhesive, the surface of the plate to be bonded should be degreased with material approved by the Overseeing Organisation and then completely dried. Care is needed to prevent warping of plates during grit blasting and tolerances should therefore be specified for straightness.

## HMEP NG 1732AR STRUCTURAL BONDING

### General

1. Structural bonding involves the bonding of external plates of steel or other suitable materials (e.g. fibre reinforced composites) to the surface of a concrete structure. Only steel plates are covered in this specification. Other materials will be considered on their merit.

### Preparation and application

2. A key requirement for a successful bonded joint is the adequate preparation of the adhered surface, it is essential therefore that this elementary concept in structure adhesive bonding be given full consideration. The Overseeing Organisation will require evidence before the project commences the adequate provision for surface preparation has been made.
3. The concrete surface of an existing member will usually be contaminated and have out-of-plane imperfections and will therefore require preparation before plates are bonded to it. Grit blasting is a preferred method of removing weak materials, laitance and surface contamination. Scabbling and grinding could damage the concrete and should only be used to remove minor protuberances. The prepared surface should be dust free and surface dry. If moisture is picked up by absorbent paper pressed onto the concrete it is likely to be too damp for bonding. A heated enclosure may then be necessary. Immediately prior to the application of the thixotropic epoxy adhesive, the concrete surface shall be vacuum cleaned to remove all dust, debris, etc.
4. For successful adhesion of the resin the contact surfaces of the steel plates should be degreased and blast cleaned at the fabricators premises to grade Sa 2 of ISO 8501- as implemented by BS 7079 using clean hard angular metal grit, free of contamination to give a blasted surface (peak to trough) amplitude between 50

and 100 microns

5. Epoxy resin adhesives require care in use. Manufacturers or formulators commonly supply two-part resins in containers suitably proportioned for mixing. It is important that all the hardener is added to the resin in its container and mixed with a slow speed mechanical mixer. High speed mixing entrains air and is less efficient. The resin and hardener should be of different colours and a uniform colour indicates adequate mixing. The speed of the chemical reaction increases with the temperature generated.
6. It is important to spread the adhesive immediately after mixing to dissipate the heat generated and extend its workability time. Common practice is to spread the adhesive slightly more thickly along the centre line of the plate than at the sides of the plate. This reduces the risk of forming voids when pressing the plate loaded with adhesive against the concrete surface. Excess adhesive can then be scraped away. The use of plastic spacers maintains the minimum adhesive thickness of 1-2mm. Procedure trials should always be carried out to prove the method of application and acquaint the operatives with the material. When temperature is less than 10°C, artificial heating may be required to assist curing and maintain the ambient temperature and humidity at acceptable levels.

### HMEP CL. 1733AR QUALITY CONTROL

1. The properties of the substrate, acceptance for suitability of products and systems, the conditions for their application and final properties of the hardened products and systems shall be subject to quality control which shall be undertaken using tests and observations given in Appendix 17/2.
2. A record of any test results shall be provided

### HMEP NG 1733AR QUALITY CONTROL

1. Details of testing to be carried out by the Contractor and test certificates to be supplied on repair materials should be abstracted selectively from Table NG 17/2 and scheduled in Appendix 17/7.
2. The testing detailed in Table NG 17/2 is not necessarily exhaustive and other tests may be required.

Table NG 17/2: Summary of tests and observations for quality control

Test No (clause A.9.2 EN 1504-10)	Characteristic	Method <i>[Where multiple tests, select one and delete tests not required]</i>	Frequency	Injection methods	Application of mortar or concrete	Limiting value
1	Delamination	Hammer sounding	Once before application on substrate and once per element after application		Required	No delamination permitted
2	Cleanliness	Visual wipe test	Immediately before application	Optional	Required	No dust/loose material
4	Roughness	Visual Sand test (EN 1766) or Profile meter (EN ISO 3274 and EN ISO 4288)	Once before application		Optional	To standard of trial panel.
5	Substrate tensile strength	Pull-off test (EN 1542)	When instructed prior to commencing repairs		Optional	<i>[Define: e.g. &gt;1.2N/mm<sup>2</sup> with no individual result &lt;1.0MPa]</i>
6	Crack width and depth	Mechanical or electrical gauge, Core and visual (EN 12504-1) or Ultrasonic (EN 12504-4)		Optional		
7	Crack movement	Mechanical or electrical gauges		Optional	Special applications	
8	Vibration	Accelerometer				
9	Moisture content	Visual or Laboratory analysis Resistivity test Relative humidity probes	Before and during application	Optional <sup>1</sup>		As instructed by Overseeing Organisation <i>[insert limits]</i>

Table NG 17/2: Summary of tests and observations for quality control: continued

10	Temperature of substrate	Thermometer	Throughout application	Optional	Required	Within manufacturer's specified range
11	Carbonation depth	Phenolphthalein test (EN 14630)			Special applications	
12	Chloride content of substrate	EN 14629	As instructed by Overseeing Organisation		Special applications	<i>[Specify limit e.g. ≤0.20% by weight of cement]</i>
14	Crack contamination	Core and chemical analysis		Optional		
20	Identity of all repair products	Written certification	Before use	Required	Required	
21	Ambient temperature	Thermometer	Throughout application	Required	Required	Within manufacturer's specified range
22	Ambient humidity	Hygrometer (ISO 4677-1 & 2)	Throughout application	Optional		Within manufacturer's specified range
23	Precipitation	Visual	During application	Optional	Required	Repair products not to be applied unless protected
27	Consistence of repair product	Slump test, Vebe test or Flow table test (EN 12350-1 to 5) Flow trough test (EN 13395-3) Flow trough test, Flow table test or Overhead test (EN13395-1, 2 and 4)	As instructed by Overseeing Organisation		Required	As instructed by Overseeing Organisation
28	Air content of fresh concrete	Pressure method (EN 12350-7)	As instructed by Overseeing Organisation		Optional	As instructed by Overseeing Organisation – <i>[depends on aggregate size]</i>

Table NG 17/2: Summary of tests and observations for quality control: continued

32	Permeability of repair	Karsten test Core and penetration test (EN 12390-8)	Once to assess efficiency	Optional	Optional	As instructed by Overseeing Organisation <i>[e.g. manufacturer's specified value]</i>
33	Degree of filling cracks	Core and visual (EN12504-1)	Two 20mm diameter cores per crack when instructed	Required		
34	Thickness of repair	Dip plastic material	As instructed by Overseeing Organisation		Required	As instructed by Overseeing Organisation
		Core (EN 12504-1)				As instructed by Overseeing Organisation
		Cover meter				As instructed by Overseeing Organisation – <i>[allowance shall be made for tolerance on accuracy of the cover meter.]</i>
35	Adhesion of repair material	Cross cut test (EN ISO 2409-6 & ISO 4624) Pull-off test to EN1542	Once for each type of surface or member		Required	2.0MPa within repair material, 1.2MPa repair material/parent concrete interface
36	Compressive strength	Core (EN 12504-1) or Rebound test (EN 12504-2)	(To be defined by Overseeing Organisation)		Required on repair material Optional on substrate	To comply with class R4
37	Density of hardened concrete	Oven dry method (EN 12390-7)	(To be defined by Overseeing Organisation)		Optional	As instructed by Overseeing Organisation
38	Shrinkage cracking in repair material	Visual Mechanical gauge	Once		Required	

**Table NG 17/2: Summary of tests and observations for quality control: continued**

39	Presence of voids in and behind hardened repair material	Core and visual (EN12504-1) or Radiography Ultrasonic pulse (EN 12504-4)	Once		Optional	Very low
45	Colour and texture of finished surface	Visual	Each element		Optional	

**Notes:**

1. Moisture content of crack and surrounding concrete

**HMEP NG SAMPLE APPENDIX 17/7 – TESTING ON CONCRETE REPAIR TO BE CARRIED OUT BY CONTRACTOR**

Test No	Characteristic	Method	Frequency	Limiting value

*[Notes to compiler*

1. Refer to table NG 17/2 for guidance
2. Test number relates to clause A.9.2 in BS EN 1504-10:2003
3. Frequency may be reduced with Overseeing Organisation’s approval when a track record of consistent, satisfactory results achieved]

## HMEP NG SAMPLE APPENDIX 17/8 – SCHEDULE FOR THE SPECIFICATION OF REPAIR PRODUCTS

Products for concrete injection to clause 1730AR

Characteristic <sup>1</sup>	Schedule (Select one)	Applicable to crack repair type
Type of repair	Force transmitting (F) Ductile (D) Swelling fitted (S)	
Adhesion by slant shear strength	Required Not required	F
Glass transition temperature <sup>2</sup>	Required Not required	F & D
Chloride content <sup>3</sup>	Required Not required	F
Watertightness <sup>2</sup>	Required Not required	D
Expansion ratio and evolution <sup>2</sup>	Required Not required	D
Corrosion behaviour <sup>2</sup>	Required Not required	S

[Notes to compiler

1. By specifying products to EN 1504-5, many performance characteristics are required by default (see EN 1504-5 table 1a, 1b and 1c). This appendix clarifies the optional characteristics required depending on the type of crack to be filled (see NG1730AR.3) and intended use.
2. Reactive polymer binder only.
3. Hydraulic binder only].

- 4. By specifying the appropriate class, requirements for compressive strength, chloride ion content, adhesive bond, restrained shrinkage/expansion and carbonation resistance are defined (refer to EN 1504-3 Table 3.*
- 5. Test Method depends on exposure conditions. Compliance with freeze/thaw test is deemed to satisfy thunder shower and dry cycling.*
- 6. Only required for trafficked areas.*
- 7. Not required if any thermal compatibility testing is specified].*

## HMEP NG SAMPLE APPENDIX 17/8 – SCHEDULE FOR THE SPECIFICATION OF REPAIR PRODUCTS

Products for structural and non-structural repair to clause 1731AR

Characteristic	Schedule (Select one option)	Comment
Product class <sup>1</sup>	R4, R3, R2, R1	Refer EN 1504-3 Table 3
Thermal compatibility – freeze/thaw <sup>2</sup>	Required Not required	Test to EN 13687-1
Thermal compatibility – thunder shower <sup>2</sup>	Required Not required	Test to EN 13687-2
Thermal compatibility – dry cycling <sup>2</sup>	Required Not required	Test to EN 13687-4
Elastic modulus	Required Not required	Test to EN 13412
Skid resistance <sup>3</sup>	Class I, Class II, Class III Not required	Refer EN 1504-3 Table 3
Co-efficient of thermal expansion <sup>4</sup>	Required Not required	Test to EN 1770
Capillary absorption (water permeability)	Required Not required	Test to EN 13057

*[Notes to compiler*

1. *By specifying products to EN 1504-5, many performance characteristics are required by default (see EN 1504-5 table 1a, 1b and 1c). This appendix clarifies the optional characteristics required depending on the type of crack to be filled (see NG1730AR.3) and intended use.*
2. *Reactive polymer binder only.*
3. *Hydraulic binder only.*

4. *By specifying the appropriate class, requirements for compressive strength, chloride ion content, adhesive bond, restrained shrinkage/expansion and carbonation resistance are defined (refer to EN 1504-3 Table 3.*
5. *Test Method depends on exposure conditions. Compliance with freeze/thaw test is deemed to satisfy thunder shower and dry cycling.*
6. *Only required for trafficked areas.*
7. *Not required if any thermal compatibility testing is specified].*

## ADDITIONAL GUIDANCE

### HMEP AG 1700 001

During the review of the various specifications and standard details it was noted that there were a number of variations in the method of specification for concrete for general purposes.

Manual of Contract Documents for Highway Works Specification for Highways Works Clause 1000 - Strength Classes of Concrete and Constituent Materials for Pavement Layers in the Specification for Highways Works provides a useful table for the comparison of the different classes of concrete that may be specified for highways works. This has been simplified for reference purposes below.

BS EN 206-1, BS 8500-2, BS EN 13877-2			BS 8500-1, BS EN 13877-1	Specification for Highways Works Clause
Designed Concrete	Standardised Prescribed Concrete	Designated Concrete		
CC37			C32/40	1001 to 1034 and 1044
			C32/40	
			C25/30	
CC18.5	ST4	GEN 3	C16/20	1030
CC14	ST3	GEN 2	C12/15	
CC9	ST2	GEN 1	C8/10	
CC7	ST1	GEN 0	C6/8	

## SERIES 1800 – STRUCTURAL STEELWORK

While the cost of structural steel may be considerable when compared to other highways construction and maintenance materials, its use in the replacement or repair of structures is not a common occurrence for local highway authorities. Where structural steel is specified it is normally as part of an individual project relating to a single structure, and is designed, specified and detailed to comply with current standards applicable at that time. Most local authority works are associated with the routine inspection and maintenance of steel structures, and not with the replacement or renewal of the structure itself. This assumption was mirrored in the review of the information provided by local highways authorities, where no indication of the use of structural steel was found.

Following the review of the information provided by local highways authorities and other external bodies it is considered that the current Specification for Highways Works should be used for this Series, subject to updates by the user to comply with changes to the Specification required by the adoption of Eurocodes (see Additional Guidance note HMEP AG 1800 001- SERIES SUBSTITUTION)

The table below lists the current Clauses from the Specification for Highways Works.

Series 1800 – Specification for Highway Works to HMEP Comparison			
Clause Number	Manual of Contract Documents for Highway Works Volume 1 - Specification for Highway Works	HMEP Clause Number	Highways Maintenance Efficiency Programme
1801	General 2		
1802	Surface Preparation and Protection Against Corrosion 2		
1803	(05/04) Amendments and Additions to BS 5400 : Part 6 : 1999 (Amd. No. 13715, 3 October 2002)		

## ADDITIONAL GUIDANCE

### HMEP AG 1800 001 - SERIES SUBSTITUTION

Series 1800 of the Manual of Contract Documents for Highway Works Specification for Highways Works has not been updated to include current developments in Euro Codes.

It is recommended that consideration is given to the use of:

The Steel Construction Industry publication SCI P382 Steel Bridge Group: Model Project Specification For the Execution of Steelwork in Bridge Structures,

Published by The Steel Construction Institute, Silwood Park, Ascot, Berkshire SL5 7QN (ã 2009 The Steel Construction Institute)

<http://www.steel-sci.com/>

## WINTER MAINTENANCE MATERIALS

The HMEP specification brief is directed towards the identification of potential costs savings through the standardisation of materials. From the information received from contributing authorities for winter maintenance works the most common form of material used for de-icing public highways is road salt. The use of road salt for de-icing and the specification of winter maintenance services and materials has been the subject of research outside the Manual of Contract Documents Specification for Highways Works, and detailed guidance is available from the source listed below.

Following review of available documents it is not felt that there is a need to contribute further to the subject.

The Specification of winter maintenance services and materials has been the subject of research outside the Specification for Highways Works, and detailed guidance is available from the following sources.

### ADDITIONAL GUIDANCE

#### SOURCES OF GUIDANCE AND INFORMATION

##### HMEP WINT 1.0

The Winter Maintenance Handbook provides a comprehensive good practice guide and knowledge base for winter service practitioners. Local Highway Authorities are advised to consider the Winter Maintenance Handbook when preparing their winter maintenance service plans and salt management plans, in undertaking winter service operations and in the development of collaborative arrangements to ensure resilience of the network.

The WINTER MAINTENANCE HANDBOOK can be found from the following link;

<http://www.ukroadsliasongroup.org/en/utilities/document-summary.cfm?docid=C7214A5B-66E1-4994-AA7FBAC360DC5CC7>

##### HMEP WINT 2.0

For reference, the interim and final reports into the response of England's transport system to severe winter weather (the Quarmby reports), many of the recommendations which are now addressed by the Winter Maintenance Handbook, can be accessed from the following link:

<http://webarchive.nationalarchives.gov.uk/20111014014059/http://transportwinterresilience.independent.gov.uk/>

### HMEP WINT 3.0

The UK Roads Board and the Chartered Institution of Highways and Transportation are also sources of information that can be used by winter service practitioners. The respective websites can be accessed from the following links;

<http://www.ukroadsliaisongroup.org/en/UKRLG-and-boards/uk-roads-board/index.cfm>

<http://www.ciht.org.uk/>

### HMEP WINT 4.0

The Salt Association members work with Local Highway Authorities, national authorities and private business across the country to help maximise winter maintenance operation, through the supply of materials (rock salt and other related products) and in the application of innovative technology. The Association website can be accessed from the following link;

[www.saltassociation.co.uk](http://www.saltassociation.co.uk)

### HMEP WINT 5.0

The specification for salt for use on the country's road network is BS 3247:2011, Specification for salt for spreading on highways for winter maintenance, which can be purchased at the following link;

[BS 3247:2011 - Specification for salt for spreading on highways for winter maintenance – BSI British Standards](#)

## ABBREVIATIONS USED

<b>ADEPT</b>	Association of Directors of Environment, Economy, Planning and Transport <a href="http://www.adeptnet.org.uk/">http://www.adeptnet.org.uk/</a>
<b>APSE</b>	Association for Public Service Excellence <a href="http://www.apse.org.uk/">http://www.apse.org.uk/</a>
<b>BBA</b>	British Board of Agreement <a href="http://www.bbacerts.co.uk/">http://www.bbacerts.co.uk/</a>
<b>DMRB</b>	Design Manual for Roads and Bridges <a href="http://www.dft.gov.uk/ha/standards/dmr/index.htm">http://www.dft.gov.uk/ha/standards/dmr/index.htm</a>
<b>HAPAS</b>	Highway Authorities Product Approval Scheme <a href="http://www.bbacerts.co.uk/product-approval/hapas.aspx">http://www.bbacerts.co.uk/product-approval/hapas.aspx</a>
<b>HCD</b>	Highways Construction Details – Volume 3 of the Manual of Contract Documents for Highways Works <a href="http://www.dft.gov.uk/ha/standards/mchw/vol3/index.htm">http://www.dft.gov.uk/ha/standards/mchw/vol3/index.htm</a>
<b>HTMA</b>	Highways Term Maintenance Association <a href="http://www.htma.co.uk/">http://www.htma.co.uk/</a>
<b>LHAs</b>	Local Highways Authorities
<b>LoTAG TAG</b>	London Technical Advisers Group Technical Advisers Group <a href="http://www.lgtag.com/">http://www.lgtag.com/</a>
<b>MCHW</b>	Manual of Contract Documents for Highway Works <a href="http://www.dft.gov.uk/ha/standards/mchw/index.htm">http://www.dft.gov.uk/ha/standards/mchw/index.htm</a>
<b>NG</b>	Notes for Guidance on the Specification for Highway Works - Volume 2 of the Manual of Contract Documents for Highways Works <a href="http://www.dft.gov.uk/ha/standards/mchw/vol2/index.htm">http://www.dft.gov.uk/ha/standards/mchw/vol2/index.htm</a>
<b>SHW</b>	Specification for Highways Works- Volume 1 of the Manual of Contract Documents for Highways Works <a href="http://www.dft.gov.uk/ha/standards/mchw/vol1/index.htm">http://www.dft.gov.uk/ha/standards/mchw/vol1/index.htm</a>
<b>TfL</b>	Transport for London
<b>W-mH</b>	Well-maintained Highways UK Roads Liaison Group – Well - Maintained Highways

Unless specifically defined otherwise the definitions of terms used in this document are those in BS 6100, Glossary of Building and Civil Engineering Terms.

## TECHNICAL ABBREVIATIONS USED

<b>AASHTO</b>	American Association of State Highway and Transportation Officials
<b>AAV</b>	Aggregate Abrasion Value
<b>AISI</b>	American Iron and Steel Institute
<b>AMD</b>	Amendment to British Standard
<b>ASR</b>	Alkali Silica Reaction
<b>ASTM</b>	American Society for Testing and Materials
<b>BBA</b>	British Board of Agrément
<b>BRE</b>	Building Research Establishment Ltd
<b>BS</b>	British Standard
<b>BSI</b>	British Standards Institution
<b>CBM</b>	Cement Bound Material
<b>CBR</b>	California Bearing Ratio
<b>CHS</b>	Circular Hollow Section
<b>CP</b>	British Standard Code of Practice
<b>EN</b>	European Standard
<b>FTD</b>	Flat Traffic Delineator
<b>HAPAS</b>	Highway Authorities' Product Approval Scheme
<b>HCD</b>	Highway Construction Details
<b>HMSO/TSO</b>	Her Majesty's Stationery Office/The Stationery Office
<b>HSE</b>	Health and Safety Executive
<b>ISO</b>	International Organization for Standardization
<b>MCV</b>	Moisture Condition Value
<b>MDPE</b>	Medium Density Polyethylene
<b>PC</b>	Portland Cement
<b>PRD</b>	Percentage Refusal Density
<b>PSV</b>	Polished Stone Value
<b>PVC</b>	Polyvinyl Chloride
<b>RHS</b>	Rectangular Hollow Section
<b>SI</b>	Statutory Instrument
<b>SMC</b>	Saturation Moisture Content
<b>TRL</b>	(formerly TRRL) Transport Research Laboratory (formerly Transport and Road Research Laboratory)
<b>UKAS</b>	United Kingdom Accreditation Service
<b>PVC-U</b>	Un-plasticised Polyvinyl Chloride
<b>XLPE</b>	Cross-linked Polyethylene
<b>DC</b>	direct current
<b>dft</b>	dry film thickness
<b>ggbs</b>	ground granulated blast furnace slag
<b>mc</b>	moisture content
<b>mdft</b>	minimum dry film thickness (of paint)
<b>omc</b>	optimum moisture content
<b>pfa</b>	pulverised-fuel ash