VOLUME 2 HIGHWAY STRUCTURES: DESIGN (SUB SUBSTRUCTURES AND SPECIAL STRUCTURES), MATERIALS

SECTION 3 MATERIALS AND COMPONENTS

PART 5

BA 47/99

WATERPROOFING AND SURFACING CONCRETE BRIDGE DECKS

SUMMARY

This Advice Note is an updated version of BA 47/94, which provided information for the detailing, and construction of waterproofing and surfacing of concrete decks of highways bridges. It is intended as an adjunct to BD 47 (DMRB 2.3.4).

INSTRUCTIONS FOR USE

1. Remove BA 47/94, which is now superseded by BA 47/99, from DMRB 2.3.5 and archive this sheet as appropriate.

2. Insert BA 47/99 into DMRB 2.3.5.

3. Archive this sheet as appropriate.

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THE HIGHWAYS AGENCY

THE SCOTTISH EXECUTIVE DEVELOPMENT DEPARTMENT

THE NATIONAL ASSEMBLY FOR WALES
CYNULLIAD CENEDLAETHOL CYMRU

DEPARTMENT OF THE ENVIRONMENT FOR NORTHERN IRELAND

Waterproofing and Surfacing of Concrete Bridge Decks

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Contents

Chapter

1. INTRODUCTION

General

1.1 This Advice Note is an updated version of BA 47/94, which provided information for the detailing, and construction of waterproofing and surfacing of concrete decks of highways bridges. It is intended as an adjunct to BD 47 (DMRB 2.3.4).

1.2 Some methods of preparing concrete surfaces and the make-up and application of certain types of waterproofing system may give rise to health and safety hazards not only for operatives but to members of the general public. The use of such systems in sensitive locations needs to be taken into account when selecting waterproofing systems and appropriate restrictions applied where necessary. Risks may also arise to plants, agricultural crops and livestock and the pollution of water. Where restrictions, protection or monitoring is considered necessary to protect the public and others then these should be specified in Appendix 1/23 of the Notes for Guidance on the Specification for Highway Works (MCHW 2).

1.3 Except where a standard specified in this document implements or is technically equivalent to a Harmonised European Standard or to a European Standard adopted for use within the European Economic Area after 31 December 1985, any requirement for products or materials to comply with the specified standard shall be satisfied by compliance with

(i) a relevant standard or code of practice of a national standards institution or equivalent body of any member state of the European Economic Area

or (ii) any relevant international standard recognised in any member state of the European Economic Area

or (iii) a relevant technical specification acknowledged for use as a standard by a public authority of any member state of the European Economic Area

or (iv) traditional procedures of manufacture of a member state of the European Economic Area where these are the subject of a written technical description sufficiently detailed to permit assessment of the goods or materials for the use specified

provided that the proposed standard, code of practice, technical specification or technical description provides in use levels of safety, suitability and fitness for purpose equivalent to those required by the specified standard in so far as they are not inconsistent with the 'Essential Requirements' of the Construction Products Directive (89/106/EEC).

Scope

1.4 This Advice Note amplifies the requirements for waterproofing and surfacing of concrete bridge decks contained in BD 47 (DMRB 2.3.4) and the Specification for Highway Works hereinafter called the Specification (MCHW 1).

Implementation

1.5 This Advice Note should be used forthwith on all schemes for the construction, improvement and maintenance of trunk roads, including motorways, currently being prepared, provided that, in the opinion of the Overseeing Organisation, this would not result in significant additional expense or delay. Design Organisations should confirm its application to particular schemes with the Overseeing Organisation.

2. DEFINITIONS

2.1 The definitions given in BD 47 (DMRB 2.3.4) refer to those expressions pertinent to bridge deck waterproofing and surfacing that are used in that Standard. For other definitions see:

BS 6100: Glossary of Building and Civil Engineering Terms

3. DRAINAGE

Surface Water Drainage

3.1 The bulk of surface water on a deck is best removed by the provision of adequate falls to suitable drainage outlets. Longitudinal gradients should be a minimum of 1 in 100. The removal of surface water may be improved by means of:

(i) Local falls in the channels or hardshoulders between closely spaced gullies.

(ii) A continuous drainage channel.

Guidance on the hydraulic design and spacing of road gulleys is given in TRRL Contractor Report No 2. Drainage outlets should intercept surface water and wherever possible be positioned adjacent to the deck joints. There may be no need for gullies on short span bridges.

Sub-surface Drainage

3.2 Bituminous surfacing materials are water permeable and there should be falls and outlets to allow this water to drain away. Where this is not possible or the rate of drainage would be slow, sub-surface drainage may be provided using horizontal perforated tubes or vertical pipe drains or other means. Pipe drains should be a minimum of 40mm diameter to avoid becoming blocked.

3.3 The position of the outlets of sub-surface drainage pipes should be such that any discharge will not harm other parts of the structure or provide a hazard to traffic or pedestrians. It is possible in freezing conditions for icicles to form from the drainage outlets.

3.4 A place where water is likely to be trapped is at a deck movement joint on a low section of deck, which forms a barrier to the natural drainage from the surfacing. Reference should be made to BD 33 (DMRB 2.3) for methods of dealing with this situation.

Drainage of Service Bays

3.5 The requirements of paragraph 3.3 apply also to the drainage of service bays. Pipe drains should be a minimum of 40mm diameter to avoid becoming blocked.

Porous Asphalt Surface Course

3.6 HD 27 (DMRB 7.2.4) and HA 79 (DMRB 4.2.4) gives guidance on the properties and use of porous asphalt surface course on trunk roads, including motorways.

4. DETAILING OF DECK WATERPROOFING

4.1 Attention given to deck detailing during design will assist in ensuring the effectiveness of the waterproofing. However at the design stage the type of waterproofing system to be used may not be known and the deck detailing should therefore allow for both prefabricated and liquid applied systems. Detailing should ensure continuity throughout including central footways, central reserves, verges, service bays and under kerbs.

4.2 Arrises should be chamfered or rounded as sharp edges may cut into the membrane and some prefabricated sheets can be weakened when bent round a sharp edge. Liquid applied membranes have a tendency to draw away from sharp arrises resulting in local thinning of the membrane. In these cases a stripe coat may be necessary to maintain the specified minimum membrane thickness.

4.3 Fillets should be formed in sharp internal angles to ensure the fitting and shaping of prefabricated sheets into the angle. Efforts by the operative to seat the sheets into a sharp angle can result in weakening or hidden damage to the membrane. There is also a tendency for the sheet to resist bending sharply into an angle and to draw away leaving a hollow, which may give rise to blistering and puncturing when the surfacing is applied.

4.4 With spray applied coatings the spray tends not to enter right into the angle but to build up thickness on the adjacent margins resulting in a line of thinning of the membrane in the angle. Spraying technique, material rheology and equipment should be selected to avoid this fault.

4.5 Prefabricated sheets and liquid applied waterproofing systems each have their own advantages in certain situations. Prefabricated sheets generally cost less and the membrane is complete when delivered to site, hence giving assurance of quality, minimum thickness etc. Liquid applied membranes are only completed during application and stringent quality control measures are required on site to ensure that correct proportioning, mixing and minimum thicknesses are achieved.

4.6 Where speed of laying is important the liquid applied membranes show an advantage which may justify any extra cost. Any limitation of system type would need to be inserted in the contract documents. The liquid applied membranes are also suitable for application to irregular areas and where obstacles are present as they avoid the cutting and trimming that is required with the prefabricated types. Liquid applied systems may also be advantageous where an existing deck requires waterproofing or re-waterproofing and where the concrete finish is not in accordance with current standards. Such systems should be laid within their specified thickness limitations and without causing any detrimental effect to either the performance of the waterproofing system or the asphaltic surfacing above.

4.7 For the top slab of a buried structure (see BD 47 (DMRB 2.3.4)) the upper surface is waterproofed with a system listed in the Specification. The Additional Protective Layer is required and precautions against damage during construction will be as for decks that are to be surfaced (see Clause 2002 of the Specification (MCHW 1)).

5. CONCRETE DECK CONSTRUCTION

Concrete Deck Finish

5.1 Freedom from laitance in compliance with Clause 2001 of the Specification (MCHW 1) is essential to obtain sound adhesion of the waterproof membrane to the deck.

Curing Membranes

5.2 The use of curing liquids, compounds and membranes can adversely affect the adhesion of the waterproofing system to the concrete deck. Reference to the restricted use of curing membranes is made in Clause 1710.5 of the Specification (MCHW 1).

6. WATERPROOFING SYSTEMS

6.1 The selection of Permitted Waterproofing Systems for use on highway bridge decks does not in itself give automatic assurance that those systems will adhere adequately to the concrete. A site procedure trial may be considered where the concrete is other than Portland cement or has been impregnated or received other preparation.

6.2 Where during a site procedure trial the adhesion is found to be unsatisfactory it is likely to be due to incompatibility at the concrete/primer interface.

7. INSTALLATION AND WORKMANSHIP

7.1 The most opportune periods for installing waterproofing systems are the spring, summer and autumn when climatic conditions are most favourable.

7.2 In order that a waterproofing system remains fully effective it is essential that uniform adhesion (see BD 47 (DMRB 2.3.4) Appendix B) to the deck is maintained throughout its life. Adhesion failure will permit water with de-icing salts and contaminants to press under the membrane thus negating the effectiveness of the waterproofing system. In addition the debonded interface may lead to the local disruption of the surfacing and the formation of potholes.

7.3 The use of ventilating layers, partial bonding or bond breakers is not permitted in BD 47 (DMRB 2.3.4) as they provide an easy passage for water to pass under the membrane. The pumping action produced by the passage of vehicle wheels exacerbates the problem and leads rapidly to the general failure of the adhesion and disruption of the surfacing.

Primers

7.4 Primers for waterproofing systems should be applied in accordance with the requirements specified in the BBA Roads and Bridges Agrément Certificate for the particular system.

7.5 Where solvent based primers are used any excess primer that has not been removed is likely to 'skin over' but give the appearance of being dry. The trapped solvent may expand rapidly under the application of hot bitumen and may lead to failure of the membrane.

Sheet Membranes

7.6 When laying prefabricated sheet membranes the lapping of the sheets on the deck should be such that water will drain away from the exposed edge. Wherever possible the sheets should be laid in the direction that the additional protective layer or surfacing will be laid and compacted by roller.

7.7 Exposed edges and temporary stop ends left at the end of a days work or threatened onset of rain should be sealed to prevent penetration of water under the membrane.

Blistering

7.8 Moisture in the concrete deck, incomplete coverage by primers, unevaporated solvents in primers, and general outgassing can lead to blistering of prefabricated sheet waterproofing and liquid applied membranes. The waterproofing system and the additional protective layer should be covered as quickly as possible with the road surfacing in order to minimise the risk of blistering which is usually more prevalent in the late spring and early summer during clear sunny weather.

Outgassing

7.9 The design of many bridge decks includes voids, which contain air, and air may be held within the concrete itself. This contained air can move in and out of voids with temperature and barometric pressure changes and such air movement through pores in the bridge deck top surface can cause pinholes in primers and thence blister the membrane. It is less likely to affect sheet membranes, but can cause pinholes, blowholes or blisters in liquid applied membranes whilst in the partially cured condition. Outgassing can cause bubbles to repeatedly burst through the liquid membrane.

7.10 Research has shown that the predominant cause of outgassing is a change in concrete temperature, which gives rise to expansion of air in the pore structure of the concrete. The rate of outgassing is related to both the rate of temperature change and to the air permeability of the concrete. However it should be noted that outgassing has also been shown to occur where primers containing solvents have been used. Outgassing from this source has been shown to be significantly greater than that due to temperature change alone.

7.11 Under the conditions which simulate outgassing, it has been found that thin fast gelling membranes are most susceptible to blistering while the thin slower gelling membranes are most prone to pinholing.

Bonding Bitumen

7.12 Where oxidised bitumen is used as a bonding agent for sheet material it should not be heated to a temperature in excess of that necessary to secure an effective bond. The required temperature of the bitumen

will depend on the air and deck temperature at the time of laying. It should not be heated above 260°C and it is normally suitable for application at a maximum temperature of 240°C. Overheating and prolonged heating of the bitumen compound will drive off volatile oils leaving the residue hard and brittle and unsuitable for bonding layers together. A suitable thermometer should be used to monitor the temperature of the bonding bitumen. The use of bonding bitumen is covered in BS 8000 Part 4.

8. PROTECTION OF WATERPROOFING

Additional Protective Layer

8.1 Bituminous material is placed as soon as possible on the waterproofing system to protect the waterproofing system during subsequent construction operations. The purpose is to protect the waterproofing system from damage eg during kerb laying and from the large aggregate when the hot surfacing materials are rolled and when surfacing courses are planed off during maintenance. The red tint is specified as a visible warning that the waterproofing system is being approached when planing off surfacing materials.

8.2 Kerbs are bedded directly onto the additional protective layer.

8.3 The bituminous material should not exceed 20mm nominal thickness in order to retain stability and it should not be used as a regulating course.

9. SURFACING ON CARRIAGEWAYS

9.1 Road surfacing laid over the waterproofing and additional protective layer consists of base and wearing courses. On flexible pavement roads the wearing course on the bridge deck should be as for the road generally and it is usually economic for it to be carried through at the same thickness.

9.2 On certain accommodation bridges used by farmers concrete surfacing is suitable as it is more easily cleaned after use by cattle. Where concrete surfacing is used, the additional protective layer is not required over the waterproofing system.

9.3 The thickness of the basecourse is usually varied to provide the required shaping and profile, with the thickness of the wearing course remaining constant.

9.4 The waterproofing systems listed in the Specification (MCHW 1) are designed to perform satisfactorily when overlaid with 100mm minimum thickness of surfacing.

Maintenance Re-surfacing on Carriageways

9.5 In special circumstances where the thickness of surfacing to be laid on the waterproofing system is required to be less than 100mm, special surfacing material designed for thin layers may need to be used. In these cases the Overseeing Department should be consulted for advice on the choice of waterproofing system.

9.6 Where reduced surfacing thicknesses are used it may not be possible to use road studs of the anchored type.

9.7 When a tack coat between membrane and surfacing or additional protective layer is not included as part of the waterproofing system, a site procedure trial to establish satisfactory adhesion may be required.

10. SURFACING ON FOOTWAYS, CENTRAL RESERVES AND VERGES

10.1 Flexible surfacing is generally preferred for footways, central reserves and verges. The joints between precast or stone flags may develop cracks, which will admit water and should only be used where the fill material beneath is concrete.

10.2 Where a loose fill material is used beneath paving a suitable arrangement would comprise 50mm of coated macadam base course and either 20mm to 25mm of dense bituminous surfacing complying with BS 4987 or 25mm of mastic asphalt complying with BS 1447. Mastic asphalt to BS 6925: types R988 and T1097 is unsuitable for paving.

11. REFERENCES

1 Design Manual for Roads and Bridges

Volume 2: Section 3: Materials and Components

BD 33 Expansion Joints for Use in Highway Bridge Decks (DMRB 2.3.6)

BD 47 Waterproofing and Surfacing of Concrete Bridge Decks (DMRB 2.3.4)

Volume 4: Section 2: Drainage

HA 79 Edge of Pavement Details for Porous Asphalt Surface Course (DMRB 4.2.4)

Volume 7: Section 2: Pavement Design and Construction

HD 27 Pavement Construction Methods (DMRB 7.2.4)

2 Manual of Contract Documents for Highway Works

Volume 1: Specification for Highway Works (MCHW 1)

Volume 2: Notes for Guidance on the Specification for Highway Works (MCHW 2)

3 British Standards

BS 1447: 1988 Mastic asphalt (limestone fine aggregate) for roads, footways and paving in buildings

BS 4987: 1988 Coated macadam for roads and other paved areas

BS 6100: Glossary of building and civil engineering terms

BS 6925: 1988 Mastic asphalt for building and civil engineering (limestone aggregate)

BS 8000 Part 4: 1989 Code of Practice for waterproofing

CP 144: Part 4: 1970 Roof coverings: mastic asphalt

4 Other Documents

TRRL Contractor Report No 2: The drainage capacity of BS road gullies and a procedure for estimating their spacing.

12. ENQUIRIES

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

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