TRANSPORT RESEARCH LABORATORY

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LABORATORY TESTS ON HIGH-FRICTION SURFACES FOR HIGHWAYS

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This report describes work commissioned by the Road Engineering and Environmental Division of the Highways Agency under E090A/HM. Surface Treatments.

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EXECUTIVE SUMMARY

The suite of tests described in this report were developed as part of research project E090A/HM, *Surface Treatments*, for the Road Engineering and Environmental Division of the Highways Agency.

Currently, resin-based high-friction surfaces are specified in terms of component materials and an application method based on the original epoxy-resin/calcined bauxite system. Whilst these high-friction surface systems provide the properties expected of them, the present method of specification tends to restrict innovation in this field. Therefore, laboratory-based tests are needed which can measure the physical properties of the complete system in order to compare, and subsequently specify, these products.

This report contains a series of test protocols designed to provide the basis of the *Highway Authorities Products Approval Scheme* for high-friction surface systems to be run by the British Board of Agrément on behalf of Highway Authorities including the Highways Agency. The use of these tests should allow innovation and development of high-friction surface systems whilst ensuring that there is a reasonable assurance that any products certified in line with results from these tests will work effectively with the expected durability.

The main tests proposed are for scuffing, wear and tensile adhesion, all of which are simulative. Additionally, a subsidiary test for thermal movement, three conditioning procedures for heat-ageing, freeze/thaw and diesel susceptibility and three optional tests for installation temperature, substrate texture depth and concrete substrate are proposed. The optional tests would only be used in response to specific claims by the Supplier of the system being tested. The scuffing test would be carried out as a preliminary test to screen-out any totally unsuitable high-friction surface systems. A further simulative test, the peel-off test, was developed but not included in the assessment programme.

A limited programme of the tests has been carried out for comparison with a series of road trials.

LABORATORY TESTS ON HIGH-FRICTION SURFACES FOR HIGHWAYS

ABSTRACT

A series of test protocols are proposed which define a laboratory test programme to assess the performance of high-friction surface systems. The programme involves three simulative tests (for scuffing, wear and tensile adhesion), a thermal movement test and three conditioning tests (for heat-ageing, freeze/thaw and diesel susceptibility). Three optional tests (installation temperature, substrate texture depth and concrete substrate) are also proposed for use when specific claims for the system under test by the Supplier need to be substantiated and a general procedure for assessing the visual condition of trial sites is proposed. An additional test, the peel-off test, was considered but is not included in the proposed assessment programme.

1. INTRODUCTION

High-friction surfaces are provided by systems which are required to have skid-resistant properties that cannot be obtained with natural aggregates and which are required to withstand very severe traffic stresses. Therefore, these systems are generally limited to those that hold calcined bauxite, or other equivalent artificial aggregates, by use of resin-based binders. Surface dressing with calcined bauxite and premium polymer-modified bitumen can be used, but only on relatively low-stressed sites, whilst other surfacings, such as thin surfacings and polymer-modified slurry surfacing (microsurfacing or microasphalt), are not considered to be capable of providing the necessary skid-resistant properties.

High-friction surface systems with resin-based binders are generally specified for site locations where there is a requirement to achieve, and maintain, a high level of in-service skid resistance. For the Trunk road network, different levels of skid resistance are specified dependent on the 'risk rating' of the site location (HD 28/94, DMRB 7.3.1). The higher the classification of site (that is, those requiring a high level of skid resistance), the higher is the required minimum polished stone value (PSV) of the aggregates to be used. The highest classification in HD28/94 requires a PSV of 70+, which can generally only be achieved consistently with calcined bauxite (or other artificial material) as the aggregate.

Recently, many new proprietary high-friction surface systems have been developed and introduced for this specialist market. This, in turn, has generated a highly competitive market with costs generally reducing over the past few years. In surface dressing terms, high-friction surfaces account for less than 0.5 per cent of the market, but costs per square metre are about ten times higher than those for conventional surface dressings. For these treatments to be cost effective, they must be able to withstand the high shearing and turning forces generated by traffic, while at the same time giving a long service life. For epoxy resin based surfaces to Clause 924 of the *Specification of Highway Works*, or *SHW* (MCHW1), in-service performance is relatively well documented, but the durability and long term road performance of many of the new high-friction surface systems using different resins are still being established.

Furthermore, Clause 924 of the *SHW* is currently drafted as a 'recipe/method' specification based on the original epoxy resin surface system. In order to allow the *SHW* to cover all materials that may prove to be suitable, it will need to include either separate 'recipe/method' specification clauses for each generic type of resin, with an additional clause being required each time a new resin type is brought onto the market, or for the clause to be totally revised and based on performance-related criteria.

In order to move towards a performance-related approach, the Transport Research Laboratory (TRL), in association with the Highways Agency (HA), the British Board of Agrément (BBA), the County Surveyors' Society (CSS) and others, have developed a series of test protocols for laboratory tests to ascertain the potential effectiveness and durability of high-friction surfaces. These tests are being offered for inclusion into the programme of laboratory tests to be used by the *Highway Authorities Products Approvals Scheme* (HAPAS) for high-friction systems under which BBA Roads and Bridges Certificates will be issued to suppliers of complying systems, which can then be called up in future specifications by HA and CSS.

This report describes the proposed testing protocols evaluated, which are:

SIMULATIVE

Scuffing;

Wear;

Tensile adhesion; and

Peel-off (subsequently excluded from the HAPAS test programme).

CONDITIONING

Heat-ageing;

Freeze/thaw; and

Diesel susceptibility.

MOVEMENT

Thermal movement.

OPTIONAL TESTS

Installation temperature;

Substrate texture depth; and

Concrete substrate.

The test methods are given in Appendices G to Q with common methods for the preparation of specimens in Appendices A to C and for the determination of parameters in Appendices D to F. In addition, a general procedure for visually assessing the condition of trial sites is given in Appendix R.

The tests can be performed on specimens with the high-friction surface applied to slabs of any material type that is used for wearing courses of roads. However, for the proposed testing protocols, the standard substrate material will be 30/14F rolled asphalt to BS 594: Part 1 (BSI, 1992), Table 3, Column 3/2 with 20mm pre-coated chippings. This mixture is selected because it is the most common material type onto which high-friction systems are laid in the United Kingdom at present and because it is considered that the results obtained will be typical for the performance of the high-friction surfaces applied to other asphalt materials[1]. The concrete substrate test is an optional test to demonstrate that a high-friction surface can also be applied to a brushed concrete substrate.

2. TEST METHODS

2.1 SIMULATIVE

2.1.1 Scuffing

The scuffing test is designed to simulate the turning action of traffic and to assess the bond of the high-friction surface to the underlying surfacing. Earlier work carried out on epoxy resin based surfaces containing different amounts of epoxy resin (Denning & Carswell, 1983) showed that this test can identify a potential for de-bonding. The test protocol is given in Appendix G.

2.1.2 Wear

The wear test is designed to simulate the long term wear caused by turning traffic (but not the equivalent ageing). The viability of this test has been demonstrated in trials (Nicholls & Carswell, 1997). The test protocol is given in Appendix H.

2.1.3 Tensile Adhesion

The tensile adhesion test is designed to evaluate the bond between the high-friction surface and the substrate to which it is applied, or the adhesion between the aggregate and the binder if that is less. The test was originally developed for bridge deck waterproofing systems, and its relevance to high-friction surfaces has not been fully assessed. The test method is given in Appendix J.

2.1.4 Peel-Off

The peel-off test is also designed to evaluate the bond between the high-friction surface and the substrate to which it is applied. The test has not yet been fully assessed, and it is possible that a shear test designed to mimic forces applied to the surface by vehicles stopping abruptly may be more appropriate. It was decided not to include this test in the test programme to assess high-friction surface systems, but the test method is given in Appendix Q for reference.

2.2 CONDITIONING

2.2.1 Heat-Ageing

The change of properties with time, including the effects of temperature, ultra-violet light and other climatic variations, can be an important factor in the durability, and hence effectiveness, of high-friction surfaces. The heat-age test is designed to establish the effect of ageing due to oxidation at the higher temperatures experienced by pavements. The test protocol is given in Appendix K.

2.2.2 Freeze/Thaw

The freeze/thaw test is designed to establish the environmental ageing effect, in terms of changes in properties, on the high-friction surface caused by repeated freezing and thawing. The test protocol is given in Appendix L.

2.2.3 Diesel Susceptibility

The diesel susceptibility test is designed to establish the environmental ageing effect, in terms of changes in properties, on the high-friction surface caused by fuel spillages. The test protocol is given in Appendix M.

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[1] In this Report and its Appendices, the term "asphalt" is taken to be any mixture of aggregate and either bitumen, tar or a combination thereof (each either modified or unmodified) and therefore includes mixture types such as rolled asphalt, macadam, mastic asphalt, stone mastic asphalt and thin surfacing materials.

2.3 MOVEMENT

2.3.1 Thermal Movement

The thermal movement test is designed to establish the stresses applied to the substrate by thermal movement to try to identify high-friction surface systems that are not thermally compatible with the underlying material. It is proposed initially to give the results for information rather than to use them to classify the systems. The test protocol is given in Appendix N.

2.4 OPTIONAL TESTS

2.4.1 Installation Temperature

The installation temperature test is designed to check that the high-friction surface can be successfully applied when the surface temperature of the substrate is outside the range 5°C to 35°C. The test compares the performance in the scuffing test of specimens with the high-friction surface applied in a laboratory at the extreme temperature claimed to the performance of specimens with the high-friction surface applied in a laboratory at a temperature of 20°C. The test protocol is given in Appendix P.

2.4.2 Substrate Texture Depth

The substrate texture depth test is designed to check that the high-friction surface can be successfully applied when the texture depth of the substrate is outside the range 0.5mm to 2.0mm. The test compares the performance in the scuffing test of specimens with the high-friction surface applied in a laboratory to a substrate with the extreme texture depth to the performance of specimens with the high-friction surface applied in a laboratory to a substrate with a texture depth between 0.9mm and 1.2mm. The test protocol is given in Appendix P.

2.4.3 Concrete Substrate

The concrete substrate test is designed to check that the high-friction surface can be applied successfully to brushed concrete as well as to an asphalt substrate. This test is only carried out to verify specific claims for the high-friction surface system under test by the Supplier that the system can be applied to a concrete substrate. However, given the wide range of conditions in which a concrete substrate type can occur on site, compliance only indicates that the high-friction surface can be applied to a concrete substrate, not that such a use will be successful. The test compares the performance in the scuffing test and in the tensile adhesion test at 20°C of specimens with the high-friction surface applied in a laboratory to a concrete substrate with the performance of specimens with the high-friction surface applied in a laboratory to an asphalt substrate. The test protocol is given in Appendix P.

3. TEST PROGRAMME

The test programme for any high-friction surface system would be carried out in four groups with a review between the first and the latter three, which will generally be carried out together. The groups are:

Group 1 - Preliminary	Scuffing	Initial assessment test
Group 2 - Primary	Wear	Tests to assess the classification of a system
	Tensile Adhesion	
	Heat-Ageing	
Group 3 - Informative	Freeze/Thaw	Tests initially for information only
	Diesel Susceptibility	
	Thermal Movement	
Group 4 - Optional	Installation Temperature	Tests required to verify specific claims for the system by the Supplier
	Substrate Texture Depth	
	Concrete Substrate	

The scuffing test is used as a screening test to check the general viability of the high-friction surface system in Group 1 before too much work is carried out. The main testing is carried out with the Group 2 tests while Group 3 comprises tests that are for information only, at least until their validity is demonstrated, and Group 4 are the optional tests, which verify specific claims by the Supplier of the high-friction surface system being evaluated under test.

4. CONCLUSION

A test programme consisting of individual test procedures has been developed for the assessment of resin-based high-friction surfaces. The simulative tests have shown reasonable correlation with road performance to date (Nicholls & Carswell, 1997) whilst the expected values from the subsidiary tests can be derived from those obtained on the

materials for which road trials are under way. Therefore, this approach is considered to provide a logical procedure for comparing, and ultimately specifying, these products.

5. ACKNOWLEDGEMENTS

The work described in this paper was carried out in the Civil Engineering Resource Centre (Resource Centre Manager Mr P G Jordan) of the Transport Research Laboratory with Mr J C Nicholls as Project Manager and Mr J F Potter as Quality Audit and Review Officer. TRL Project Engineering developed the equipment for the Peel-Off and Movement Test and I G Carswell and Mrs K J Lloyds carried out the testing procedures to confirm their practicality.

6. REFERENCES

Manual of Contract Documents for Highway Works. Her Majesty's Stationery Office, London.

Volume 1: Specification for Highway Works (MCHW1).

Design Manual for Roads and Bridges, Volume 7: Pavement Design and Maintenance. Her Majesty's Stationery Office, London.

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BRITISH STANDARDS INSTITUTION (1992). Hot Rolled Asphalt for Roads and Other Paved Areas; Part 1. Specification for Constituent Materials and Asphalt Mixtures. *BS 594: Part 1: 1992*. British Standards Institution, London.

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APPENDIX A : REQUIREMENTS FOR ASPHALT SLABS

A.1 SCOPE

This Appendix describes the requirements for asphalt slabs for subsequent testing with a high-friction surface applied.

A.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

A.3 COMPOSITION

The slabs shall be asphalt consisting of 30/14F rolled asphalt to column 3/2 of BS 594: Part 1 with 50 pen bitumen and 20mm pre-coated chippings applied at 70 per cent shoulder-to-shoulder coverage. The chippings shall have a polished stone value of not less than 60 measured in accordance with BS 812: Part 114.

A.4 COMPACTION, DIMENSIONS AND TEXTURE

Each slab shall receive sufficient compaction to ensure that it is adequately robust not to be damaged by subsequent handling. Once fully compacted, the slabs shall be (305±2)mm by (305±2)mm in plan by (50±10)mm deep. The upper surface, after compaction, shall have a texture depth in accordance with Appendix D in the range 0.90mm to 1.20mm.

A.5 STORAGE AND TRANSPORTATION

Store the slabs flat so that the whole of the bottom surface is supported at a temperature of (5±2)°C. During transportation, the slabs shall continue to be supported for the whole of the bottom surface but the temperature may be outside the range of (5±2)°C for a total period of not more than 7 days provided it does not exceed 30°C.

A.6 PRECISION

There is no result from this procedure, and therefore there is no associated precision.

A.7 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100 Methods for sampling for analysis. *BS 598: Part 100: 1987*. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1989). Testing aggregates, Part 114. Method for determination of the polished-stone value. *BS 812: Part 114: 1989.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1992). Hot Rolled Asphalts for Roads and Other Paved Areas; Part 1, Specification for Constituent Materials and Asphalt Mixtures. *BS 594: Part 1: 1992.* British Standards Institution, London.

APPENDIX B: REQUIREMENTS FOR CONCRETE SLABS

B.1 SCOPE

This Appendix describes the requirements for concrete slabs for subsequent testing with a high-friction surface applied.

B.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 5328 and BS 1881: Part 101 apply.

B.3 COMPOSITION

The slabs shall be concrete consisting of Designated Mix PAV2 in accordance with Section 5 of BS 5328: Part 2 using Portland cement, 20mm maximum nominal size aggregate and 50mm nominal slump.

B.4 COMPACTION, CURING, DIMENSIONS AND TEXTURE

B.4.1 Each slab shall receive sufficient compaction to ensure that it is adequately robust not to damaged by subsequent handling. A brushed finished shall be applied to the surface.

B.4.2 The slabs shall be cured in water at 20°C for not less than 28 days in accordance with BS 1881: Part 111 and then either in air for a further 28 days or in an oven at a temperature of (105±5)°C for 2 days. Any weak layer of laitance on the top face of the slab shall be removed either mechanically or by brushing with a wire brush.

B.4.3 The cured slabs shall be either (305±2)mm by (305±2)mm or (150±2)mm by (150±2)mm in plan by (50±10)mm deep. The upper surface, after removal of laitance, shall have a texture depth in accordance with Appendix D in the range 0.50mm to 0.70mm.

B.5 STORAGE

Store the slabs indoors on an edge so that the whole of one edge is supported at a temperature above freezing.

B.6 PRECISION

There is no result from this procedure, and therefore there is no associated precision.

B.7 REFERENCES

BRITISH STANDARDS INSTITUTION (1983). Testing Concrete; Part 101. Method of sampling fresh concrete on site. *BS 1881: Part 101: 1983.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1983). Testing Concrete; Part 111. Method of normal curing of test specimens (20°C method). *BS 1881: Part 108: 1983.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1991, 1990). Concrete; Part 1. Guide to specifying concrete; Part 2. Methods for specifying concrete mixes; Part 3. Specifications for the procedures to be used in producing and transporting concrete. *BS 5328: Part 1: 1991, BS 5328: Part 2: 1991, BS 5328: Part 3: 1990.* British Standards Institution, London.

APPENDIX C: PROCEDURE FOR APPLYING HIGH-FRICTION SURFACES AND THE MEASUREMENT OF THE SURFACING THICKNESS

C.1 SCOPE

This Appendix describes the procedure for applying high-friction surfaces to asphalt or concrete slabs for subsequent tests and for measuring the thickness of the surface.

C.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

C.3 SUMMARY OF METHOD

High-friction surfaces are applied to slabs by either, for chemically curing binders, mixing the components of the resin for spraying or hand-installation before spreading aggregate over them or, for thermoplastic binders, by heating the pre-combined material and spreading the heated mixture across the slab.

NOTE. The installation of the high-friction surface system has to be carried out by the Applicant or his representative and witnessed by the British Board of Agrément or its agent if the subsequent test results are to be used to obtain a BBA Roads & Bridges Certificate under HAPAS.

C.4 APPARATUS

The apparatus shall consist of:

C.4.1 *Callipers*, or other suitable measuring device, capable of measuring thickness in the range 25mm to75mm to an accuracy of ±0.1mm between flat discs of (10±1)mm diameter.

C.4.2 *Specialist installation equipment* required for the specific system being applied.

C.4.3 *Containers* (chemically curing binders) in which the binder can be mixed.

C.4.4 *Spatulas, squeegees* or other instruments for mixing and spreading the binder (chemically curing binders) or system (thermoplastic binders).

C.4.5 *Heaters* (thermoplastic binders) in which the system can be heated to the required temperature.

C.4.6 *Heat-resistant gloves* (thermoplastic binders).

C.4.7 *Thermometer*, capable of measuring surface temperatures between -20°C and 50°C to ±1.0°C.

C.4.8 *Broom*, hard bristled.

C.5 PROCEDURE

C.5.1 Slab manufacture

C.5.1.1 Ensure that the required slabs, which comply with Appendix A for asphalt slabs and with Appendix B for concrete slabs, are dry and at ambient temperature.

C.5.1.2 Measure the thickness of each slab to ±0.1mm at approximately the third-points along each side, at least 30mm in from the edge, using the callipers or other suitable measuring device. Mark the points on the bottom face of the slab.

C.5.1.3 Lay sufficient slabs for the subsequent testing programme in an array of horizontal dimensions of not less than 1.2m (4 slabs) in both directions in a position and at a level to permit the high-friction surface system to be applied in the normal manner. The slabs shall be laid so that they are, and remain, level with no step of more than 3mm between:

- any pair of adjacent slabs;
- any pair of slabs and any packing inserted between them; or
- any slab and the adjacent ground, which shall be firmly compacted or of a stiff material.

NOTE 1. One practical approach is for the slabs to be laid on sand in a pit such that the top faces of the slabs when in place are at ground level. The pit can be either covered or in the open, but if covered must have adequate access for the equipment used to apply the system.

NOTE 2. A complete suite of tests, excluding optional tests, will require at least 14 slabs as follows:

Scuffing test	*3 slabs;*
Wear test	*3 slabs;*
Tensile adhesion test	*3 slabs;*
Heat-ageing test	*3 slabs;*
Freeze/thaw test	*1 slabs; and*
Diesel susceptibility test	*1 slabs.*

Additional slabs may be required as reserves in case of rejects under C.5.2.6 or C.5.3.3.

C.5.1.3 Seal the gaps between the slabs sufficiently to stop the system being applied from percolating into the gaps. If tape is used on the top surface of the slabs, ensure that the covered edge is not more than 15mm wide on any side of a slab.

C.5.2 Applying the Surface System

C.5.2.1 Check that the weather is dry, unless the installation is to be carried out undercover, and that the ambient temperature is such that the surface temperature of the slabs should be within the range (20±15)°C after any heat pre-treatment of the substrate and before the high-friction surface is applied. If the weather is not suitable, postpone applying the surface until the conditions are appropriate.

C.5.2.2 The Applicant or his representative shall carry out the pre-treatment for the high-friction surface system to the array of slabs in the same manner that normally occurs on site. Measure the ambient and surface temperatures to ±1°C; if the system involves any heat pre-treatment of the substrate, the surface temperature shall be measured both before and after pre-treatment. If the surface temperature, after any pre-treatment, is outside the range (20±15)°C, defer applying the surface until the conditions are appropriate, when any necessary pre-treatment shall be repeated.

C.5.2.3 The Applicant or his representative shall apply the surface to the array of slabs in the same manner that the system is normally applied on site.

C.5.2.4 Remove any tape used to seal the gaps and separate the slabs so that they are not connected by the layer of high-friction surface and there is none of the surface on the sides of slabs. Ensure that there are no ridges around the perimeter of the slabs or, if tape is used to seal the gaps, the perimeter of the surfacing.

C.5.2.5 Allow the surface to cool and/or cure in accordance with normal procedures for use on site (as far as practicable). For systems were the aggregate is not encapsulated prior to being applied to the substrate, remove any excess and loosely held aggregate from the surface by brushing with a hard bristled broom.

C.5.2.6 Check the specimens for adequate and uniform coverage, surface defects and slab damage. Reject any specimens that might bias the results in any manner.

C.5.2.7 Brush each specimen to remove any loosely adhering aggregate.

C.5.3 Thickness

C.5.3.1 Measure the thickness of the slab plus surface to ±0.1mm at the eight points marked in C.5.1.2 using the callipers or other suitable measuring device.

C.5.3.2 Calculate the mean thickness of surface applied to ±0.2mm from the differences between the thickness of the slab plus surface (C.5.3.1) and the thickness of the slab alone (C.5.1.2) at the eight points.

C.5.3.3 Reject any specimens whose thickness is outside the normal range for that system, as claimed by the Applicant.

C.5.4 Storage

Store specimens on asphalt slabs in accordance with A.5 and store specimens on concrete slabs in accordance with B.5.

C.6 PRECISION

The precision of the test method for measurement of thickness of high-friction surface has still to be determined.

C.7 REPORTING OF RESULTS

The test report shall include the mean thickness of high-friction surface to the nearest 0.1mm separately for each slab.

C.8 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX D: TEST PROCEDURE FOR DETERMINATION OF TEXTURE DEPTH

D.1 SCOPE

This Appendix describes the method of test for determining the sand-patch texture depth of both the substrate and the high-friction surface.

D.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 and BS 598: Part 105 apply.

D.3 SUMMARY OF TEST METHOD

The average texture depth at the centre of a specimen is determined by measuring the diameter of the circle formed when a known quantity of silica sand to a specified grading is spread evenly over the surface.

D.4 APPARATUS

The apparatus shall consist of the apparatus listed in clause 4.1 of BS 598: Part 105 except that the measuring cylinder shall be:

- of (25±1)mL total capacity for concrete substrate or high-friction surface; and
- of (50±1)mL total capacity for asphalt substrate.

D.5 PROCEDURE

D.5.1 Carry out a single measurement in accordance with clause 4.3 of BS 598: Part 105 in the centre of the specimen.

D.5.2 Remove the sand from the specimen by vacuuming, brushing or turning the specimen face down, as appropriate.

D.6 CALCULATIONS

Calculate the texture depth of the specimen as

(high-friction surfaces & concrete substrates)

$$\text{Texture depth} = \frac{31,830}{D^2}\ \text{mm}$$

(asphalt substrates)

$$\text{Texture depth} = \frac{63,660}{D^2}\ \text{mm}$$

where D is the mean diameter of the sand patch in millimetres.

D.7 PRECISION

The precision of the test method is approximately $\sqrt{10} = 3.16$ times that given in clause 4.6 of BS 598: Part 105.

D.8 REPORTING OF RESULTS

The test report shall include the texture depth to the nearest 0.1mm.

D.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1990). Sampling and examination of bituminous mixtures for roads and other paved areas; Part 105. Methods for test for the determination of texture depth. *BS 598: Part 105: 1990.* British Standards Institution, London.

APPENDIX E: TEST PROCEDURE FOR DETERMINATION OF SKID RESISTANCE VALUE

E.1 SCOPE

This Appendix describes the method of test for determining the skid-resistance value by pendulum tester.

E.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

E.3 SUMMARY OF TEST METHOD

The skid-resistance value of the surface at the centre of a specimen is determined by the angle through which a slider attached to a pendulum rises after being released from a known height and coming into contact with the surface for a specific distance at the bottom of the arc.

E.4 APPARATUS

The apparatus shall consist of:

E.4.1 *Pendulum*, manufactured to the design of the Road Research Laboratory, as described in Road Note 27 and as illustrated in Figure E.1. All bearings and working parts of the instrument shall be enclosed as far as possible, and all materials used shall be treated to prevent corrosion under wet conditions. The pendulum shall have:

- a spring-loaded rubber-coated slider (E.4.2) mounted on the end of a pendulum arm (E.4.3) so that the sliding edge is (510±1)mm from the axis of suspension;
- means for setting the support column of the instrument vertical;
- a base of sufficient mass to ensure the equipment remains stable during the test;
- means for raising and lowering the axis of suspension of the pendulum arm so that the slider can:
  - * swing clear of the surface of the specimen; and
  - * be set to slide over a fixed length of flat surface of (126±1)mm (a gauge with this distance marked, as shown in Figure E.2, is required);
- means of holding and releasing the pendulum arm so that it falls freely from a horizontal position;
- a pointer of nominal length 300mm (E.4.4); and
- two circular scales (C scale and F scale) calibrated for nominal sliding lengths of 126mm and 76mm, respectively, on a flat surface marked from 0 to 150 at intervals of five units.

E.4.2 *Slider* shall comply with E.4.2.1 and E.4.2.3 to E.4.2.9 (wide slider) or E.4.2.2 to E.4.2.9 (narrow slider).

NOTE. The narrow slider is usually used on curved specimens in the polished stone value test for aggregates in accordance with BS 812: Part 114. Whilst the use of a narrower slider should, in theory, make no difference (the forces being the same, even though over a narrower width), this may produce different values from those obtained in the validation trials with the wide slider in practice. However, the narrow slider is preferred because the width of wear in the scuffing test is relatively limited.

E.4.2.1 *Wide Slider* shall consist of a rubber pad (76.2±0.5)mm wide, (25.4±1.0)mm long (in the direction of swing) and (6.35±0.5)mm thick. The rubber shall be vulcanised into its base and the combined mass of the slider and base shall be (32±5)g.

E.4.2.2 *Narrow Slider* shall consist of a rubber pad (31.75±0.5)mm wide, (25.4±1.0)mm long (in the direction of swing) and (6.35±0.5)mm thick. The rubber shall be vulcanised into its base and the combined mass of the slider and base shall be (20±5)g.

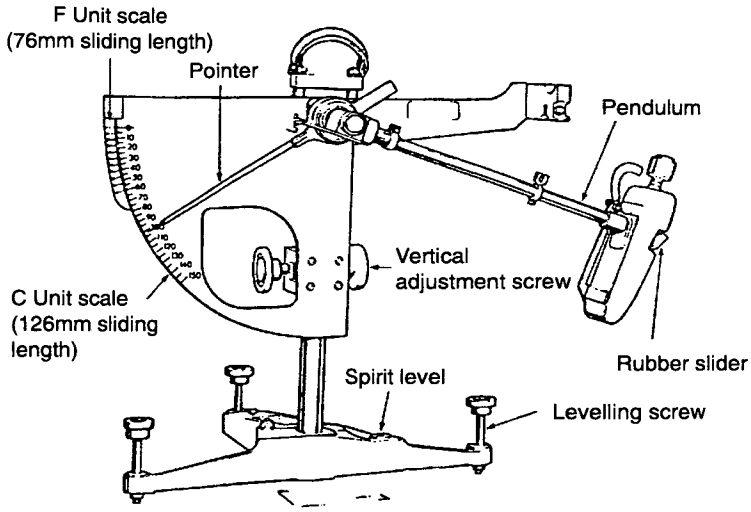

Fig. E.1 The pendulum

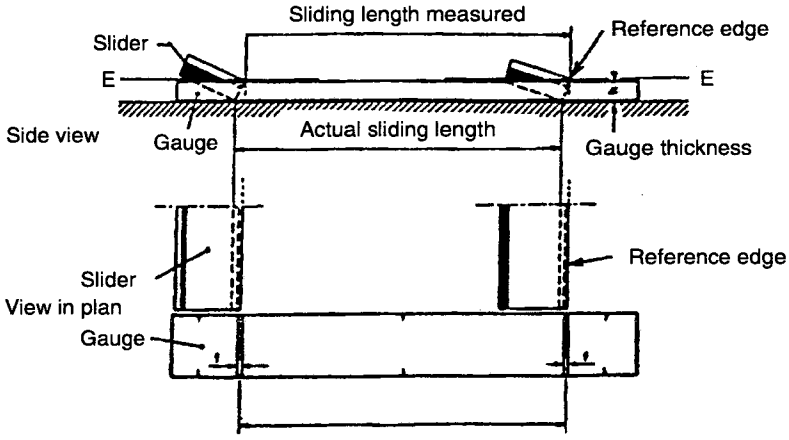

Fig. E.2 Sliding length gauge

E.4.2.3 The slider shall be held on a rigid base with a central pivoting axis which shall be mounted on the pendulum arm in such a manner that, when the arm is at the lowest point of its swing with the trailing edge of the slider in contact with the test surface, the plane of the slider is angled at (26±1) degrees to the horizontal. In this configuration, the slider shall be able to turn about its axis without obstruction to follow unevenness of the surface as the pendulum swings.

E.4.2.4 The slider shall be spring-loaded against the test surface. The normal static force on the slider, as set by the procedure defined in the equipment's calibration instructions, shall be (22.2±0.5)N in its median position; the change in the static force on the slider shall be not greater than 0.2N/mm deflection of the slider.

E.4.2.5 The initial resilience and hardness of the slider shall comply with Table E.1. It shall have a certificate of conformity including the name of the manufacturer and the date of manufacture. A slider shall be discarded when the IRHD value, measured in accordance with ISO 7619, falls below the minimum tolerance given in Table E.1 or not later than three years after manufacture.

E.4.2.6 The working edges of the slider shall be square and clean-cut, and the rubber free from contamination by, for example, abrasive or oil.

E.4.2.7 Before using a new slider, it shall be conditioned to achieve a width of striking edge of (2±1)mm, as shown in Figure E.3.

NOTE 1. This conditioning may be achieved by setting up the pendulum and carrying out five swings on a dry surface with a skid resistance value above 40 and a texture depth in the range 0.4mm to 1.0mm measured by the sand-patch method (Appendix D). This may be followed by a further twenty swings on the same surface wetted. A sample of aggregate with PSV 55 after use for the Aggregate Abrasion Value test (BS 812: Part 113) provides a suitable surface. The same surface can be used repeatedly for this purpose.

NOTE 2. High-friction surfaces and the aggregates used in them are unsuitable for conditioning because they cause excessive wear relative to natural aggregates.

E.4.2.8 The slider shall be discarded when the width of the striking edge, as shown in Figure E.3, exceeds 3mm or when it becomes excessively scored or burred. The slider can be reversed to a new edge, which will need to be conditioned.

NOTE. On high-friction surfaces, a slider can normally only be used on two or three tests per edge before it becomes unserviceable.

E.4.2.9 The slider, or rubber to manufacture sliders, shall be stored in a dry, watertight bag in the dark at a temperature in the range (15±10)°C. The cooler the storage temperature, the longer the properties in Table E.1 will be retained. Should the temperature of the rubber fall below 15°C for a period in excess of one day during storage or during a series of tests, the slider shall be raised to a temperature of (35±5)°C for a period of (18±6)hours before use on a subsequent occasion. The slider shall be at ambient temperature when used.

E.4.3 *Pendulum arm*, with a mass, including the slider, of (1.50±0.03)kg. The centre of gravity shall lie on the axis of the arm at a distance of (410±5)mm from the centre of suspension.

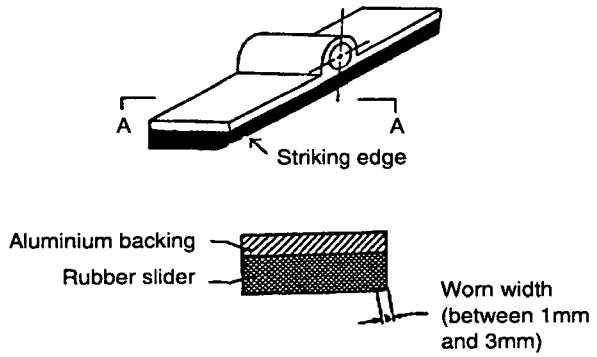

Fig. E.3 Slider assembly illustrating the maximum wear on the striking edge

E.4.4 *Pointer*, balanced about the axis of suspension, which indicates the position of the pendulum arm throughout its forward swing and moving over the circular scale; the mass of the pointer shall be not more than 85g. The friction in the pointer mechanism shall be adjustable so that, with the pendulum arm swinging freely from a horizontal position, the outward tip of a nominal 300mm long pointer may be brought to rest on the forward swing of the arm at a point 10mm below the horizontal.

E.4.5 *Thermometer*, radiation (pyrometer) or electronic with a surface probe, readable to 1°C.

E.5 SLIDER CORRECTION FACTOR

E.5.1 If tests are to be carried out with the narrow slider, carry out E.6 on one test specimen with the wide slider and then repeat E.6 at the same location with the narrow slider.

E.5.2 Calculate the narrow slider correction factor for that pendulum on that high-friction surface system by dividing the mean result with the wide slider calculated in accordance with E.7.1 by the mean result with the narrow slider calculated in accordance with E.7.1.

E.6 PROCEDURE

E.6.1 Select the wide slider unless the specimen to be measured is consistent, or uniformly trafficked, over a width of less than 75mm, when the narrow slider shall be selected. Ensure that the date of manufacture of the slider, as indicated on it, is not more than 12 months prior to the date of test. Check the condition of the slider for cuts and burrs before each test.

E.6.2 Ensure that the pendulum has been calibrated in accordance with BS 812: Part 114 within the previous twelve months.

E.6.3 Remove any remaining loosely held aggregate from the specimen by brushing with a hard-bristled broom. Condition the specimen and the supply of water for not less

TABLE E.1

Properties of the Slider

Property	Temperature (°C)				
	0	10	20	30	40
Resilience (per cent) *	43 to 49	58 to 65	66 to 73	71 to 77	74 to 79
Hardness (IRHD) ‡	53 to 65	53 to 65	53 to 65	53 to 65	53 to 65

* Rebound test in accordance with ISO 4662.

‡ International Rubber Hardness Degrees in accordance with ISO 48.

than 1 hour at a temperature of (10±2)°C for measurements on a specimen in the wear test or (20±2)°C for measurements on a specimen in any other test. Measure and record the temperature to ±1°C.

E.6.4 Place the pendulum over the centre of the specimen and adjust the levelling screws so that the pendulum support column is vertical, as indicated by the integral spirit level. Raise the axis of suspension of the pendulum so that the arm swings freely, and adjust the friction in the pointer mechanism so that, when the pendulum arm and pointer are released from the right-hand horizontal position, the pointer comes to rest at the zero position on the test scale.

NOTE. The check ensures that the pendulum is still functioning properly.

E.6.5 Adjust the height of the pendulum arm so that, in traversing the surface, the slider is in contact with it over the whole width of the slider and over the length of (126±1)mm for the wide slider and (76±1)mm for the narrow slider. A pointer fixed to the foot of the slider and a pre-marked gauge shall be used, as shown in Figure E.2.

E.6.6 Wet the surfaces of the specimen and the slider with a copious supply of water, being careful not to disturb the slider from its set position.

E.6.7 Release the pendulum and pointer from the horizontal release position using the holding button, catch the pendulum on the early portion of the return swing and record the position of the pointer on the scale to the nearest whole number. Return the pendulum and pointer to the release position by raising the slider using the lifting handle.

E.6.8 Repeat E.6.6 and E.6.7 five times. If the first five readings differ by more than three units, repeat E.6.6 and E.6.7 until three successive readings do not differ by more than three units.

E.6.9 On completion of testing, check that the equipment is still level and swing the pendulum as described in E.6.4 to ensure there has been no disturbance during testing. If any disturbance is apparent, discard the result and repeat the test.

E.7 CALCULATION

E.7.1 Correct the mean of five readings (or three successive readings if applicable) by adding the temperature correction factor given in Road Note No.27. For tests at 20°C, the correction factor is zero and, for tests at 10°C, the correction factor is -3.0.

E.7.2 If the tests were carried out using the narrow slider, correct the mean value by multiplying by the slider correction factor determined in E.5.2.

E.7.3 The skid-resistance value (SRV) is the corrected mean value.

E.8 PRECISION

The precision of the test method has still to be determined. Nevertheless, repeated tests show a standard deviation of 1.0 units, uncorrected for temperature on a fine-textured surface.

NOTE. Coarse texture, rough surfaces and variable temperatures will reduce the precision of the test.

E.9 REPORTING OF RESULTS

The test report shall include the skid-resistance value to the nearest unit.

E.10 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1989). Testing aggregates, Part 114. Method for determination of polished-stone value. *BS 812: Part 114: 1989.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1990). Testing aggregates, Part 113. Methods for determination of aggregate abrasion value (AAV). *BS 812: Part 113: 1990.* British Standards Institution, London.

INTERNATIONAL STANDARDS ORGANISATION (1986). Rubber - Determination of rebound resilience of vulcanizates. *ISO 4662: 1986.* International Standards Organisation, Geneva.

INTERNATIONAL STANDARDS ORGANISATION (1986). Rubber - Determination of indentation hardness by means of pocket hardness meters. *ISO 7619: 1986.* International Standards Organisation, Geneva.

INTERNATIONAL STANDARDS ORGANISATION (1994). Rubber, vulcanised or thermoplastic - Determination of hardness (hardness between 10 IRHD and 100 IRHD). *ISO 48: 1994.* International Standards Organisation, Geneva.

ROAD RESEARCH LABORATORY (1960). Instructions for using the portable skid-resistance tester. *Department of Scientific and Industrial Research, Road Note No.27.* Her Majesty's Stationery Office, London.

APPENDIX F: TEST PROCEDURE FOR DETERMINATION OF THE DEGREE OF EROSION AND VISUAL OBSERVATIONS

F.1 SCOPE

This Appendix describes the method of test for determining the visual condition of a specimen, including the extent of erosion that has occurred as quantified by an erosion index.

F.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

F.3 SUMMARY OF TEST METHOD

A photograph of the surface of the specimen is taken for record purposes. The erosion index is measured as the sum of values ascribed to 50mm x 50mm squares in a 2x5 grid, the individual values between 0 and 3 depending on the proportion of material eroded in that square to expose the specimen. Hence, the erosion index can have a value between 0 (no erosion) and 30 (completely eroded). The surface of the specimen is surveyed for any abnormalities.

F.4 APPARATUS

The apparatus shall consist of:

F.4.1 *Camera* with a lens of 80mm focal length taking 35mm film.

F.4.2 *Flash unit.*

F.4.3 *Camera housing* (optional) which will accommodate a 305mm by 305mm specimen plus identifying label at (500±100)mm perpendicularly from the camera whilst excluding light. The flash unit shall be capable of being installed so as to be able to illuminate the specimen at an angle of (45 ±12)° from the plane of its upper surface.

NOTE. The housing described in Appendix 2 to Road Note 27 is suitable for this purpose.

F.4.4 *Grid,* not less than 100mm wide by 250mm long divided into 50mm x 50mm squares by a steel mesh.

F.5 RECORD PHOTOGRAPH

F.5.1 Place the grid over the centre of the specimen with the longer side parallel to the wheel path and the grid over the tracked area. Place a label adjacent to the specimen giving the specimen reference number, the test regime being carried out and the number of wheel-passes completed.

F.5.2 Position the camera (500±100)mm perpendicularly over the specimen and position the flash unit so as to be able to illuminate the specimen at an angle of (45 ±12)° from the plane of its upper surface, using the camera housing if required. Adjust the focus and aperture size to the relevant settings and take a photograph of the specimen and label with the camera whilst the specimen is illuminated by flash light.

F.5.3 Store the photographs produced and retain for not less than two years.

F.6 EROSION INDEX

F.6.1 Place the grid over the centre of the specimen with the longer side parallel to the wheel path and the grid over the tracked area.

F.6.2 Assess the degree of erosion of each of the 10 grid squares according to the ratings as defined in Table F.1 and record the number of squares in each grade.

F.6.3 Calculate the erosion index by multiplying the number of squares in each grade by the respective weighting factor given in Table F.1 for that grade and add together the four sub-totals to give the erosion index.

NOTE. The erosion index will be 0 for a specimen on which the high-friction surface is still completely intact and 30 for a specimen on which the surface has been completely removed.

F.7 VISUAL OBSERVATIONS

F.7.1 Standing with a light source behind the observer, view the specimen with each of the four sides nearest to the observer in turn. Note the presence of any faults or abnormalities other than loss of coverage by the high-friction surface over parts of the specimen, as measured by the erosion index. Possible faults include:

- uniform loss of, or loose, aggregate (and hence a reduction in the spread of the aggregate that remains);
- cracking of the surface and/or the substrate; and
- de-lamination of areas of the surface from the substrate.

F.7.2 Repeat F.7.1 with the light source beyond the specimen.

F.7.3 Record any faults observed.

F.8 PRECISION

The precision of the test method has still to be determined.

G.4 APPARATUS

The apparatus shall consist of:

G.4.1 *Scuffing-wheel apparatus* consisting of a loaded wheel which bears on a specimen held in a moving table. The table moves to and fro beneath the wheel with the axle of the wheel held at an angle of (20±1)° to the vertical plane perpendicular to the direction of travel. Vertical play in both the loaded wheel bearings and the lever arm pivot point shall be less than 0.25mm. A typical layout is shown in Figure G.1.

G.4.2 *Pneumatic tyre* of outside diameter between 200mm and 205mm fitted to the wheel. The tyre shall be inflated to (3.1±0.1)bar (45psi) have a ribbed tread of not less than 1mm.

G.4.3 *Weighted cantilever arm*, to apply a load to the wheel under standard test conditions of (520±5)N, measured at the level of the top of the specimen and normal to the plane of the sample table.

G.4.4 *Sample table*, constructed so as to enable a 305mm by 305mm rectangular laboratory-prepared specimen to be held firmly in place with its upper surface horizontal, in the required tracking plane and with its centre positioned to ensure symmetrical tracking motion.

G.4.5 *Wheel-tracking machine*, constructed so as to enable the specimen to be moved backwards and forwards under the loaded wheel in a fixed horizontal plane. The centre of contact area of the tyre shall describe simple harmonic motion with respect to the centre of the top surface of the specimen with a frequency of (21±0.2) load cycles (42 passes) per 60 seconds and a total distance of travel of (230±5)mm.

NOTE. This form of motion is most readily achieved by a reciprocating drive from a cam but alternative drive mechanisms are satisfactory as long as the motion conforms with the above requirements.

G.4.6 *Carriage and frame* carrying marks to ensure the specimen is at the mid-point of its traverse (see G.5.7). Vertical movement at opposite corners of the carriage shall be less than 0.25mm.

G.4.7 *Means for temperature control*, such that the temperature of the specimen during testing is uniform and maintained constant at (45±1)°C.

NOTE. A constant temperature room enclosing the machine is one method of meeting this requirement.

G.4.8 *Tyre pressure gauge.*

G.4.9 *Pump* suitable for inflating tyres.

G.4.10 *Tyre tread gauge.*

G.4.11 *Talc, french chalk or limestone filler.*

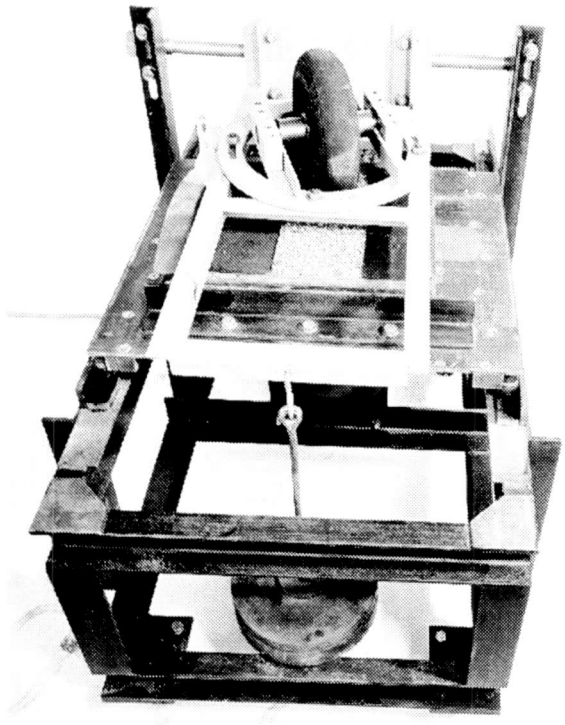

Fig. G1 Suitable scuffing machine

G.5 PROCEDURE

G.5.1 Measure the angle between the line of motion and the plane of the wheel.

G.5.2 Manufacture three 305mm by 305mm asphalt slabs in accordance with Appendix A and apply the high-friction surface to the specimens in accordance with Appendix C other than when the scuffing test is part of the installation temperature, the substrate texture depth or the concrete substrate tests. For the installation temperature, the substrate texture depth or the concrete substrate tests, manufacture three specimens in accordance with P.5.1 to P.5.5 of Appendix P.

G.5.3 Condition the specimens to a temperature of (20±2)°C. Measure the texture depth in accordance with Appendix D of the specimens prior to tracking.

G.5.4 Condition the specimens in an environment of (45±1)°C for a period of 4 to 6 hours prior to testing.

G.5.5 Check the tyre inflation and the tyre tread depth and inspect the tyre for wear or damage.

G.5.6 Place one specimen in the scuffing machine and maintain throughout the testing regime the ambient temperature at (45±1)°C. Secure the specimen rigidly to the table of the machine. If the surface of the specimen is sticky,

TABLE F.1

Assessment of Rating of Grid Squares

Grade	Area of Coating Remaining	Weighting Factor
a	Greater than or equal to 75%	x 0
b	Greater than or equal to 50% and less than 75%	x 1
c	Greater than or equal to 25% and less than 50%	x 2
d	Less than 25%	x 3

NOTE. The tabular form shown in Figure F.1 is recommended.

Grade	Number of Squares	Weighting Factor	Erosion Index
a		x 0	
b		x 1	
c		x 2	
d		x 3	
	Total: 10		Total:

Figure F.1: Specimen Erosion Index Table

F.9 REPORTING OF RESULTS

The test report shall include the erosion index to the nearest unit and any observations made as to the visual condition of the specimen.

F.10 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

ROAD RESEARCH LABORATORY (1960). Instructions for using the portable skid-resistance tester. *Department of Scientific and Industrial Research, Road Note No.27.* Her Majesty's Stationery Office, London.

APPENDIX G: TEST PROCEDURE FOR SCUFFING

G.1 SCOPE

This Appendix describes the method of test for determining the resistance to wear by scuffing of a high-friction surface at an elevated temperature.

G.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

G.3 SUMMARY OF TEST METHOD

A loaded pneumatic-tyred wheel with its axle set at an angle to the direction of motion is repeatedly passed over the surfacing of a specimen at an elevated ambient temperature. The change in texture depth and erosion index occurring after a set number of passes are used to determine the resistance of a high-friction surface system to wear by scuffing.

in a turning action at a low ambient temperature. The change in texture depth, skid-resistance value and erosion index occurring after a set number of passes are used to determine the resistance of a high-friction surface system to wear by the turning action of the wheels.

H.4 APPARATUS

The apparatus shall consist of:

H.4.1 *Road Machine*, consisting of a driven table that can rotate at 10rev/minute with a diameter of not less than 2.1m which is capable of taking not less than six 305mm x 305mm x 50mm (nominal) specimens. Two standard car wheels with 195/70 VR 14 tyres having a tread pattern similar to Michelin XDX shall be mounted vertically (1.8±0.1)m apart over the table so as to be able to run freely on the driven table whilst applying a dead load under each wheel of (5±0.2) kN. The loading wheels shall be capable of moving laterally across the specimens by a total of (160±25)mm and then return whilst the road machine is in operation; the lateral movement cycle shall take between 1 and 10 minutes. A typical layout is shown in Figure H.1.

H.4.2 *Means for temperature control*, such that the temperature of the specimens during testing is uniform and maintained constant at (10±2)°C.

NOTE. A constant temperature room enclosing the machine is one method of meeting this requirement.

H.4.3 *Tyre pressure gauge.*

H.4.4 *Pump* suitable for inflating tyres.

H.4.5 *Tyre tread gauge.*

H.4.6 *Talc, french chalk or limestone filler.*

H.4.7 *Thermometer*, capable of measuring surface temperatures between -20°C and 50°C to ±1.0°C.

H.5 PROCEDURE

H.5.1 Fit new tyres on both wheels of the Road Machine. Inflate the tyres to a pressure of (2.0±0.1)bar[2] and check that the tyre tread depths are not less than 2mm.

H.5.2 Manufacture three 305mm by 305mm asphalt slabs in accordance with Appendix A and apply the high-friction surface to the slab in accordance with Appendix C.

NOTE: Up to two sets of specimens with different high-friction surface systems can be tested concurrently.

H.5.3 Condition the specimens in an environment of (10±2)°C for a period of 4 to 6 hours prior to testing. Measure the texture depth and skid-resistance value in accordance with Appendix D and Appendix E, respectively, of each specimen prior to tracking.

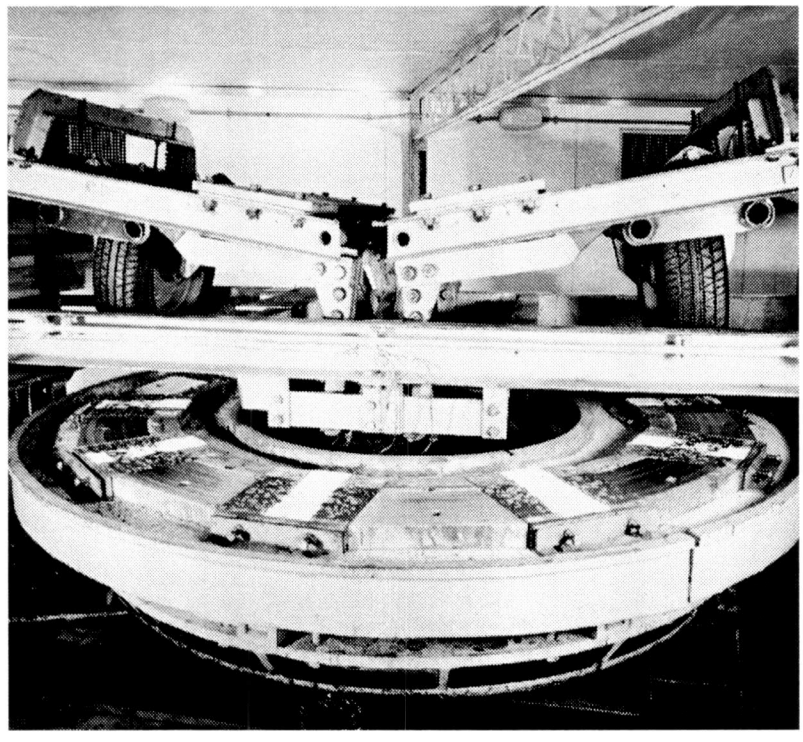

Fig. H1 Suitable road machine

[2] (2.0±0.1) bar = (200 ± 10) kN/m ≈ (29.4 ± 1.5) psi.

lightly dust it with talc, french chalk or limestone filler. Set the centre of the specimen within 10mm of the centre point of the loaded area at the mid-point of transverse. Set the machine in motion for 500 wheel-passes (250 cycles taking approximately 12 minutes).

G.5.7 Repeat G.5.5.

G.5.8 Repeat G.5.5 to G.5.7 for the other two replicate specimens.

G.5.9 Condition the specimens to a temperature of (20±2)°C. Measure the texture depth and erosion index, including carrying out a visual observation, in accordance with Appendix D and Appendix F respectively, of the specimens after tracking.

G.6 CALCULATIONS

G.6.1 The initial and final texture depths and the final erosion index for the high-friction surface are the mean values from the three determinations.

G.6.2 The loss of texture depth and the loss of skid-resistance value for the high-friction surface are calculated as

$$\text{loss} = 100 \times \frac{(\text{Initial value} - \text{Final value})}{\text{Initial value}} \%$$

G.7 PRECISION

The precision of the test method has still to be determined.

G.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the slabs manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the relevant Appendix, i.e. TRL Report 176, Appendix A or Appendix B;

c) details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface on each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) temperature at which the test was carried out;

e) initial and final tyre inflation pressures and tread depths for the test on each specimen;

f) angle between the line of motion and the plane of the wheel;

g) the initial texture depth of each specimen and the mean value for the high-friction surface system;

h) the final texture depth, erosion index and visual observations of each specimen and the mean values for the high-friction surface system;

i) The loss of texture depth with scuffing for the high-friction surface;

j) the name of the person taking technical responsibility for the test;

k) the number of this Appendix, i.e. TRL Report 176, Appendix G;

l) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

G.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX H: TEST PROCEDURE FOR WEAR

H.1 SCOPE

This Appendix describes the method of test for determining the resistance to wear by repeated turning wheels of a high-friction surface at a low temperature.

H.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

H.3 SUMMARY OF TEST METHOD

A pair of loaded pneumatic-tyred wheels revolve so as to repeatedly pass over the surfacing of a series of specimens

H.5.4 Secure the specimens in the road machine and maintain the ambient temperature at (10±2)°C throughout the testing regime. Set the machine in motion, including the lateral movement cycle, to track the samples at (10±0.5) revs/minute for (100,000±1,000) wheel-passes (50,000 revolutions taking approximately 3.5 days).

H.5.5 Measure the surface temperature as soon after the tracking is completed as practicable. When the surface temperature is in the range (10±2)°C, measure the texture depth, the skid-resistance value in the direction of tracking and the erosion index, including carrying out a visual observation, in accordance with Appendix D, Appendix E and Appendix F respectively, of each specimen. Check the tyre inflation pressures and the tyre tread depths.

NOTE. The road machine can be stopped during the test, intermediate measurements taken before the specimens are re-secured and the road machine restarted. The preferred intermediate points, should additional measurements be required, are after 10,000 wheel-passes (5,000 revolutions) and 60,000 wheel-passes (30,000 revolutions).

H.6 CALCULATIONS

H.6.1 The initial, intermediate (when taken) and final texture depths; the initial, intermediate (when taken) and final skid-resistance values; and the intermediate (when taken) and final erosion indices for the high-friction surface are the mean values from the three determinations.

H.6.2 The loss of texture depth and the loss of skid-resistance value after the relevant number of cycles for the high-friction surface are calculated as

$$\text{loss} = 100 \times \frac{(\text{Initial value} - \text{Final value or intermediate value})}{\text{Initial value}} \%$$

H.7 PRECISION

The precision of the test method has still to be determined.

H.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the slabs manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix A;

c) details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface on each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) temperature at which the test was carried out;

e) the make and model of tyres used;

f) initial, intermediate and final tyre inflation pressures and tread depths;

g) The surface temperature when each set of measurements is taken;

h) the initial texture depth and skid-resistance value of each specimen and the mean values for the high-friction surface system;

i) the intermediate (when taken) and final texture depth, skid-resistance value, erosion index and visual observations of each specimen and the mean values for the high-friction surface system;

j) the loss of texture depth and skid-resistance value with wear for the high-friction surface system;

k) the name of the person taking technical responsibility for the test;

l) the number of this Appendix, i.e. TRL Report 176, Appendix H;

m) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

H.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX J: TEST PROCEDURE FOR TENSILE ADHESION

J.1 SCOPE

This Appendix describes the method of test for determining the adhesion between a high-friction surface and the slab to which it is applied, or the adhesion between the aggregate and the binder of the system if that is less, when a tensile force, perpendicular to the plane of the specimen, is applied over an area of the high-friction surface.

J.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

J.3 SUMMARY OF TEST METHOD

A 100mm by 100mm square of the high-friction surface is cut from the adjacent surfacing and a progressive load is applied to the square until failure occurs. The test is repeated three times each at three temperatures.

J.4 APPARATUS

J.4.1 *Tensile pull-off apparatus* capable of applying a progressive load at a rate of (0.4±0.2)kN/s and having a means of measuring the applied load up to a maximum reading of at least 20kN with an accuracy of ±2 per cent of the failure load.

NOTE. A suitable tensile pull-off apparatus with a tripod holding a hydraulic jack operated by a hydraulic hand pump and the load measured by an integral load cell is shown in Figure J.1.

J.4.2 *Steel plates*, (100±2)mm x (100±2)mm and not less than 10mm thick.

J.4.3 *Saw* capable of cutting the asphalt slabs.

J.4.4 *Sharp knife or saw*, capable of cutting through the resin-based binder when cured.

J.4.5 *Wire brush.*

J.4.6 *Adhesive*, suitable for use and capable of resisting tensile stresses of not less than 4N/mm .

J.5 PROCEDURE

J.5.1 Manufacture three 305mm by 305mm asphalt slabs in accordance with Appendix A and apply the high-friction surface to the slabs in accordance with Appendix C other than when the tensile adhesion test is part of the concrete substrate test. For the concrete substrate test, manufacture one 305mm by 305mm asphalt slab in accordance with Appendix A and three 150mm by 150mm concrete slabs in accordance with Appendix B and apply the high-friction surface to the slabs in accordance with P.5.1 to P.5.5 of Appendix P. Remove all aggregate loosely adhering to the surfaces by brushing with the wire brush.

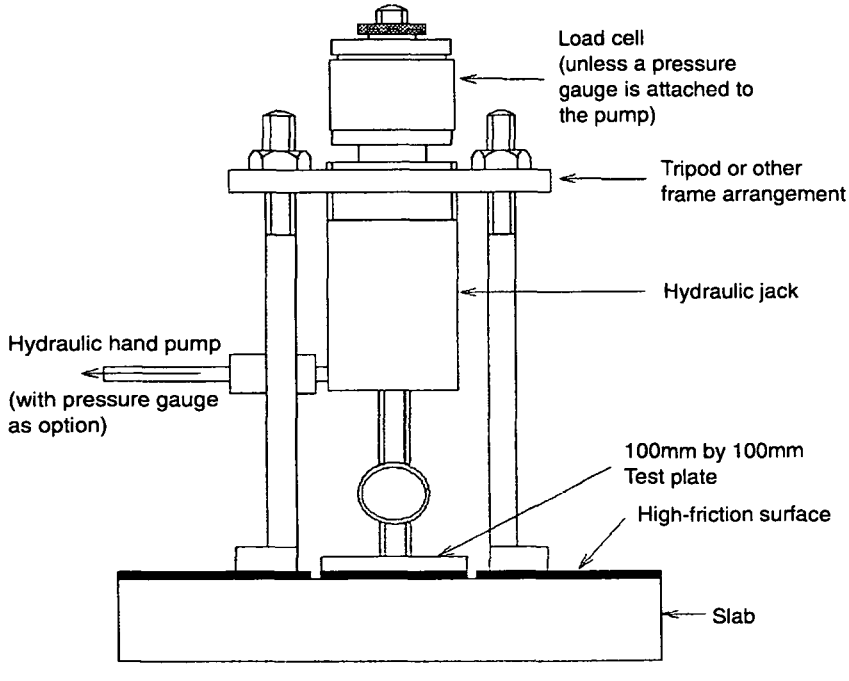

Fig. J1 Suitable arrangement for a tensile pull-off apparatus

J.5.2 Cut each 305mm by 305mm (standard) asphalt specimens into four (small) specimens of approximately 150mm by 150mm in plan. Retain three out of each four small specimens.

J.5.3 Bond a steel plate to the centre of each specimen with the adhesive. Isolate the area of high-friction surface under the plate, either before or after bonding the steel plate to the surface, by cutting just into the substrate with the sharp knife or saw without disturbing the high-friction surface.

J.5.4 Condition three small specimens (one cut from each standard specimen) at (-10±2)°C for not less than 2 hours. Locate the tensile pull-off apparatus above the surface of the plate on each specimen in turn with the pulling arm vertical and connected to the centre of the plate and load progressively at a rate of (0.4±0.2)kN/s up to failure or a load of 20kN, whichever is reached first. Record for each specimen the load at failure to ±0.1kN and the mode of failure (adhesion or cohesion and in or between which layers) if failure is reached or that failure was not reached and the maximum load applied.

J.5.5 Repeat J.5.4 for three further small specimens (one cut from each standard specimen other than when the tensile adhesion test is part of the concrete substrate test) but at a temperature of (+20±2)°C.

J.5.6 Repeat J.5.4 for three further small specimens (one cut from each standard specimen) but at a temperature of (+40±2)°C.

J.6 CALCULATIONS

The adhesion stress for each temperature are calculated as

$$\sigma_t = \frac{\left(L_{t,1} + L_{t,2} + L_{t,3}\right)}{3} 10^{-4}$$

where $L_{t,i}$ (N) is the load at failure for the i^{th}specimen and σ_t (N/mm^2) is the adhesion stress for the test at t°C. If one or more specimens did not fail, then use the maximum load applied and the adhesion stress of the high-friction surface system is greater than the value obtained. Report the adhesion stress to ±0.01N/mm^2.

J.7 PRECISION

The precision of the test method has still to be determined.

J.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the slabs manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix A;

c) details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface on each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) the load at failure on each specimen and the mean values at -10°C, +20°C and +40°C for the high-friction surface system;

e) the stress at failure at -10°C, +20°C and +40°C for the high-friction surface system;

f) a description of the failure mode;

g) the name of the person taking technical responsibility for the test;

h) the number of this Appendix, i.e. TRL Report 176, Appendix J;

i) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

J.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX K: PROCEDURE FOR HEAT-AGEING CONDITIONING

K.1 SCOPE

This Appendix describes the method of test for determining the extent to which exposure to heat ageing has a deleterious effect on the performance of a high-friction surface system in the scuffing test.

K.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

K.3 SUMMARY OF TEST METHOD

Slabs with high-friction surface applied to them are kept at an elevated temperature of 70°C. The scuffing test is applied to separate specimens after 112 days exposure at the elevated temperature. The effect of heat ageing can be assessed by comparison with results from specimens which have not been stored at an elevated temperature.

NOTE. The test can be repeated at other (intermediate) periods of exposure if details as to changes in the loss of performance are required.

K.4 APPARATUS

The apparatus shall consist of that given in Appendix G together with:

K.4.1 *Oven*, complying with BS 2648 with fan-assisted air circulation, or *temperature controlled room* fitted with thermostatic control to maintain a temperature of (70±3)°C.

K.5 PROCEDURE

K.5.1 Manufacture three 305mm by 305mm asphalt slabs in accordance with Appendix A and apply the high-friction surface to the slabs in accordance with Appendix C.

K.5.2 Measure the texture depth in accordance with Appendix D of each specimen prior to conditioning.

K.5.3 Place the specimens in the oven or temperature controlled room at (70±3)°C. Remove the specimens from the oven after 112 days ± 2 hours. After removal from the oven and prior to further testing, store the specimens flat so that the whole of the bottom surface is supported at a temperature of (5±2)°C.

K.5.4 Carry out a scuffing test in accordance with Appendix G.

K.6 CALCULATIONS

The changes for the high-friction surface due to the heat-ageing periods in:

- the final texture depth;
- the loss of texture depth; and
- the erosion index

are the arithmetic differences between the mean values obtained from specimens which have been heat-aged conditioned for 112 days and that obtained from specimens which have not been so conditioned.

K.7 PRECISION

The precision of the test method has still to be determined.

K.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the slabs manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix A;

c) the details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface on each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) temperature at which the test was carried out;

e) the initial texture depth of each specimen and the mean value for the high-friction surface system;

f) the texture depth, erosion index and visual observations of each specimen and the mean values for the high-friction surface system after 112 days heat-ageing conditioning and scuffing;

g) The loss of texture depth for the high-friction surface system with 112 days heat-ageing;

h) the name of the person taking technical responsibility for the test;

i) the number of this Appendix, i.e. TRL Report 176, Appendix K;

j) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

K.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1955). Performance requirements for electrically-heated laboratory drying ovens. *BS 2648: 1955.* British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX L: PROCEDURE OF FREEZE-THAW CONDITIONING

L.1 SCOPE

This Appendix describes the method of test for determining the extent to which exposure to freeze-thaw cycles has a deleterious effect on the performance of a high-friction surface system in the scuffing test.

L.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

L.3 SUMMARY OF TEST METHOD

A slab with high-friction surface applied to it is cycled for 16 to 17 hours at a temperature of (-20±2)°C with a brine solution covering the surface and then for 7 to 8 hours at room temperature of (25±5)°C (giving approximately 24 hours per conditioning cycle). The scuffing test is applied to the specimen after 25 conditioning cycles. The effect of freezing and thawing can be assessed by comparison with results from specimens which have not been cycled through freeze and thaw conditions.

NOTE. The test can be repeated at other (intermediate) numbers of cycles if details as to changes in the loss of performance are required.

L.4 APPARATUS

The apparatus shall consist of that given in AppendixG together with:

L.4.1 *Deep freeze chest* with forced air circulation capable of running at a temperature of (-20±2)°C.

L.4.2 *Road Tape.*

L.4.3 *Sealant*, waterproof.

NOTE. Domestic bath sealants are suitable.

L.4.4 *Polythene sheet*, thin.

L.5 PROCEDURE

L.5.1 Manufacture one 305mm by 305mm asphalt slab in accordance with Appendix A and apply the high-friction surface to the slab in accordance with Appendix C.

L.5.2 Measure the texture depth in accordance with Appendix D of the specimen prior to conditioning.

L.5.3 Wrap the road tape around the perimeter of the specimen so that the top edge of the tape is at least 5mm above the top face of the specimen. Use the sealant to form a water-tight barrier around the specimen. Fill the enclosed surface so formed with a (3±0.5) per cent brine solution to a depth of between 2mm and 3mm.

L.5.4 Place the specimen with brine solution in the chest freezer and maintain at a temperature of (-20±2)°C for between 16 and 17 hours Remove the specimen from the freezer, cover with the polyethylene sheet to prevent evaporation and store at room temperature of (25±5)°C for between 7 and 8 hours. Remove the polythene sheet and check that the brine solution has completely melted.

Note. During weekends, holidays or other times when the cycle cannot be maintained, the specimens should be kept in the frozen condition. The extension to the freeze cycle should not be more than three days.

L.5.5 Repeat L.5.4 for a total of 25 cycles, then discard the brine solution and remove the road tape and sealant.

L.5.6 After completion of the freeze-thaw cycles, thoroughly clean the high-friction surface with a detergent solution and then rinse with clean water. Repeat until the brine has been completely removed and allow to dry. Prior to further testing, store the specimen flat so that the whole of the bottom surface is supported at a temperature of (5±2)°C.

NOTE. The conditioning period for the scuffing test should ensure that the specimen is dry provided it does not start in a surface saturated condition.

L.5.7 Carry out a scuffing test in accordance with Appendix G but on a single specimen.

L.6 CALCULATIONS

The changes for the high-friction surface system due to the freeze-thaw period in:

- the final texture depth;
- the loss of texture depth; and
- the erosion index

are the arithmetic differences between the values obtained from the specimen which has been freeze-thaw conditioned for 25 cycles and the mean values obtained from specimens which have not been so conditioned.

L.7 PRECISION

The precision of the test method has still to be determined.

L.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;
b) details of the slab manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix A;
c) details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface on each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;
d) temperature at which the test was carried out;
e) the initial texture depth of the specimen;
f) the texture depth, erosion index and visual observations of the specimen after freeze-thaw conditioning and scuffing;
g) the loss of texture depth for the high-friction surface system with 25 cycles of freeze-thaw conditioning;
h) the name of the person taking technical responsibility for the test;
i) the number of this Appendix, i.e. TRL Report 176, Appendix L;
j) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

L.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX M: PROCEDURE FOR DIESEL SUSCEPTIBILITY CONDITIONING

M.1 SCOPE

This Appendix describes the method of test for determining the extent to which exposure to diesel fuel has a deleterious effect on the performance of a high-friction surface system in the scuffing test.

M.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

M.3 SUMMARY OF TEST METHOD

A slab with high-friction surface applied to it is stored with diesel covering the surface. The scuffing test is applied to the separate specimens after 48 hours conditioning. The effect of exposure to diesel can be assessed by comparison with results from specimens which have not been stored in contact with diesel.

NOTE. The test can be repeated at other (intermediate) periods of conditioning if details as to changes in the loss of performance are required.

M.4 APPARATUS

The apparatus shall consist of that given in Appendix G together with:

M.4.1 *Road Tape.*

M.4.2 *Sealant*, waterproof.

NOTE. Domestic bath sealants are suitable.

M.4.3 *Diesel fuel.*

M.4.4 *Polythene sheet*, thin.

M.5 PROCEDURE

M.5.1 Manufacture one 305mm by 305mm asphalt slabs in accordance with Appendix A and apply the high-friction surface to the slab in accordance with Appendix C.

M.5.2 Measure the texture depth in accordance with Appendix D of the specimen prior to conditioning.

M.5.3 Wrap the road tape around the perimeter of the specimen so that the top edge of the tape is at least 5mm above the top face of the specimen. Use the sealant to make form a water-tight barrier around the specimen, covering any exposed substrate around the edge.

M.5.4 Fill the enclosed surface so formed with diesel to a depth of between 2mm and 3mm. Cover with the polyethylene sheet to prevent evaporation and store at room temperature of (20±5)°C.

M.5.5 After a total of (48±2) hours, remove the sheet, discard the diesel and remove the road tape and sealant from the specimens. After removing the diesel from the surface and prior to further testing, store the specimen flat so that the whole of the bottom surface is supported at a temperature of (5±2)°C.

M.5.6 Thoroughly clean the high-friction surface with a detergent solution and then rinse with clean water. Repeat until the diesel has been completely removed and allow to dry.

NOTE. The conditioning period for the scuffing test should ensure that the specimen is dry provided it does not start in a surface saturated condition.

M.5.7 Carry out a scuffing test in accordance with Appendix G but on a single specimen within 24 hours of removing the diesel.

M.6 CALCULATIONS

The changes for the high-friction surface due to the period covered with diesel in:

- the final texture depth;
- the loss of texture depth; and
- the erosion index

are the arithmetic differences between the values obtained from the specimen which has been conditioned for diesel susceptibility for 48 hours and the mean values obtained from specimens which have not been so conditioned.

M.7 PRECISION

The precision of the test method has still to be determined.

M.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the slab manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix A;

c) details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface of each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) temperature at which the test was carried out;

e) the initial texture depth of the specimen;

f) the texture depth, erosion index and visual observations of the specimen after conditioning in diesel and scuffing;

g) The loss of texture depth for the high-friction surface with 48 hours of diesel conditioning;

h) the name of the person taking technical responsibility for the test;

i) the number of this Appendix, i.e. TRL Report 176, Appendix M;

j) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

M.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX N: TEST PROCEDURE FOR DETERMINATION OF THERMAL MOVEMENT

N.1 SCOPE

This Appendix describes the method of test for determining the thermal expansion coefficient of a high-friction surface system.

N.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply.

N.3 SUMMARY OF TEST METHOD

Two measurement points are attached 150mm apart to a specimen of high-friction surface laid on, but not bonded to, a flat, smooth surface. The distance that the measurement points move relative to each other while the high-friction surface is heated from 5°C to 45°C is measured and the proportionate change with temperature rise calculated.

N.4 APPARATUS

The apparatus shall consist of:

N.4.1 *Containers* (chemically curing binders) in which the binder can be mixed.

N.4.2 *Spatulas, squeegees* or other instruments for mixing and spreading the binder (chemically curing binders) or system (thermoplastic binders).

N.4.3 *Heaters* (thermoplastic binders) in which the system can be heated to the required temperature.

N.4.4 *Heat-resistant gloves* (thermoplastic binders).

N.4.5 *Tray(s)* of at least 200mm by 100mm in size.

N.4.6 *Sheets*, three, at least 200mm by 100mm in area of a material which will withstand the installation conditions of the particular system under test and which will not adhere to the system.

N.4.7 *Measurement device* capable of measuring the change in a distance of 150mm to ±0.01mm.

NOTE. A linear variable displacement transducer (LVDT) device, excited by a separate oscillator and fed to a scaled panel meter to give an output in millimetres, can be used.

N.4.8 *Measurement points*, three pairs, such as pillars on which, when 150mm apart, the measurement device can sit.

N.4.9 *Spacing piece* (optional) capable of ensuring that the measurement points are located so as to be 150mm (nominal) apart.

N.5 PROCEDURE

N.5.1 Spread a sheet on a tray, ensuring that there are no folds in the sheet.

N.5.2 For high-friction surface systems employing a chemically curing binder, mix the components of the binder in accordance with the recommendations for use on site from the Supplier of the system under test (as far as is practicable). The proportions of any multi-part binder system shall be strictly in accordance with the Supplier's recommendations; the equipment may need to be adapted to suit the restricted quantities of material required. Spread the binder uniformly across the tray in accordance with the recommendations for use on site from the Supplier of the system under test (as far as practicable). Spread the aggregate uniformly across the tray in accordance with the recommendations for use on site from the Supplier of the system under test (as far as is practical as far as practicable).

N.5.3 For high-friction surface systems employing a thermoplastic binder, heat the pre-mixed system to the required temperature in accordance with the recommendations for use on site from the Supplier of the system under test (as far as practicable). Spread the system uniformly across the tray in accordance with the recommendations for use on site from the Supplier of the system under test (as far as practicable).

N.5.4 Secure a pair of measurement points to the surface at 150mm apart. The measurement points can be attached either:

- by placing on the tray with the spacing piece in place before the surface is applied, when care is needed during the application to ensure that the measurement points are not disturbed;
- by inserting the measurement points into the surface before it has cured (chemically curing systems) or cooled (thermoplastic systems); or
- by gluing the measurement points to the surface once it has cured (chemically curing binders) or cooled (thermoplastic binders).

N.5.5 Allow the surface to acquire adequate strength by curing (chemically curing binders) or cooling (thermoplastic binders). Separate the sample from the sheet covering the tray at an appropriate stage of curing or cooling.

N.5.6 Place the specimen in the temperature controlled chamber and condition to (5±1)°C. Measure the separation between the posts (L_5mm).

N.5.7 Condition the specimen to (15±1)°C, (25±1)°C (optional), (35±1)°C and (45±1)°C and re-measure the separation between the posts as L_{15}mm, L_{25}mm (optional), L_{35}mm and L_{45}mm, respectively.

N.5.8 Repeat N.5.1 to N.5.7 twice to produce and measure the change in length of two further replicate specimens.

N.6 CALCULATIONS

The thermal expansion coefficient ($Exp_{Thermal}$) is calculated from the equation:

$$Exp_{Thermal} = \frac{4\,L_{45} + 2\,L_{35} - 2\,L_{15} - 4\,L_5 - 5\,K}{300} \text{ per cent / °C}$$

where K is the calibrated expansion of the measuring device between the measuring points when heated from 5°C to 45°C and using the mean values of L_5, L_{15}, L_{35} and L_{45} from the three determinations.

N.7 PRECISION

The precision of the test method has still to be determined.

N.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the high-friction surface including:

- the high-friction surface system name;
- the binder and aggregate type;
- batch numbers for the binder and aggregate;
- the mean thickness of high-friction surface applied; and

c) the separation distances at 5°C, 15°C, 25°C (optional), 35°C and 45°C for each determination and the mean value for the high-friction surface system to the nearest 0.01mm;

d) the thermal expansion coefficient of the high-friction surface system to the nearest 0.01 per cent / degree C;

e) the name of the person taking technical responsibility for the test;

f) the number of this Appendix, i.e. TRL Report 176, Appendix N;

g) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

N.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX P: TEST PROCEDURE FOR OPTIONAL TESTS

P.1 SCOPE

This Appendix describes the method of test for three tests which are optional. The tests are:

- the installation temperature test, to determine the effect of applying a high-friction surface system at temperatures outside the range 5°C to 35°C;
- the substrate texture depth test, to determine the effect of applying a high-friction surface system on asphalt substrates with a texture depth outside the range 0.5mm to 2.0mm; and
- the concrete substrate test, to determine the effect of applying a high-friction surface system on a concrete, rather than an asphalt, substrate.

The effect is assessed in terms of performance in the scuffing test only (installation temperature and substrate texture depth tests) or the scuffing test and the tensile adhesion test (concrete substrate test).

P.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply together with following:

A *set* of specimens are three specimen manufactured from slabs of the same material and having the same texture depth to which high-friction surface was applied at the same temperature.

P.3 SUMMARY OF TEST METHOD

The high-friction surface is applied to sets of slabs in the laboratory; one (control) set on asphalt slabs with a texture depth between 0.9 and 1.2mm at a temperature of 20°C and another set:

- at the claimed maximum and/or minimum temperature (installation temperature test);
- on the claimed maximum and/or minimum texture depth (substrate texture depth test); and/or
- on a concrete substrate (concrete substrate test).

The specimens produced are subject to the scuffing test and the performance compared. For the concrete substrate test, a further two sets of slabs are prepared and subjected to the tensile adhesion test and the performance compared.

P.4 APPARATUS

The apparatus shall consist of:

P.4.1 *Temperature controlled room.*

P.4.2 *Callipers*, or other suitable measuring device, capable of measuring thickness in the range 25mm to75mm to an accuracy of ±0.1mm between flat discs of (10±1)mm diameter.

P.4.3 *Specialist installation equipment* required for the specific system being applied.

P.4.4 *Containers* (chemically curing binders) in which the binder can be mixed.

P.4.5 *Spatulas, squeegees* or other instruments for mixing and spreading the binder (chemically curing binders) or system (thermoplastic binders).

P.4.6 *Heaters* (thermoplastic binders) in which the system can be heated to the required temperature.

P.4.7 *Heat-resistant gloves* (thermoplastic binders).

P.4.8 *Thermometer*, capable of measuring surface temperatures between -20°C and 50°C to ±1.0°C.

P.4.9 *Broom*, hard bristled.

P.5 PROCEDURE

P.5.1 Manufacture the appropriate number and type of 305mm by 305mm (standard) and 150mm by 150mm (small) slabs as set out in Table P.1 for the control and for the optional test(s) required. The asphalt slabs shall be in accordance with Appendix A (other than as given in Table P.1) and the concrete slabs shall be in accordance with Appendix B.

P.5.2 Measure the thickness of each slab to ±0.1mm at approximately the third-points along each side, at least 30mm in from the edge, using callipers or other suitable measuring device. Mark the points on the bottom face of the slab.

P.5.3 Condition one set of slabs in the temperature controlled room to the relevant installation temperature given in Table P.1. Measure the surface temperature of the slabs to ±1°C.

P.5.4 For high-friction surface systems employing a chemically curing binder, mix the components of the binder in accordance with the recommendations for use on site from the Supplier of the system under test (as far as is practicable). The proportions of any multi-part binder system shall be strictly in accordance with the Supplier's recommendations; the equipment may need to be adapted to suit the restricted quantities of material required. Spread the binder uniformly across the slabs in the temperature controlled room in accordance with the recommendations for use on site from the Supplier of the system under test (as

TABLE P.1

Slabs for Option Tests

Test	Number of slabs	Substrate	Substrate texture depth	Installation Temperature
Control	3 *	Asphalt	0.9mm - 1.2 mm	(20±2)°C
Installation temperature	3 †	Asphalt	0.9mm - 1.2 mm	Extreme claimed ±2°C
Substrate texture depth	3 †	Asphalt	Extreme claimed ±0.1mm	(20±2)°C
Concrete substrate	3 standard 3 small	Concrete	0.5 mm - 0.7 mm	(20±2)°C

* 4 standard slabs if the concrete substrate test is included

† 6 slabs (2 sets) if the claimed range is outside the normal range at both ends

far as practicable). Spread the aggregate uniformly across the slabs in the temperature controlled room in accordance with the recommendations for use on site from the Supplier of the system under test (as far as is practical as far as practicable).

P.5.5 For high-friction surface systems employing a thermoplastic binder, heat the pre-mixed system to the required temperature in accordance with the recommendations for use on site from the Supplier of the system under test (as far as practicable). Spread the system uniformly across the slabs in the temperature controlled environment in accordance with the recommendations for use on site from the Supplier of the system under test (as far as practicable).

P.5.6 Repeat P.5.3 to P.5.5 for each set of slabs to be tested in turn.

P.5.7 Remove any excess and loosely held aggregate from the surface on each specimen by brushing with the hard bristled broom.

P.5.8 Measure the thickness of the slab plus surface to ±0.1mm at the eight points marked in P.5.1 using the callipers or other suitable measuring device. Calculate the mean thickness of surface applied to ±0.2mm from the differences between the thickness of the slab plus surface and the thickness of the slab alone at the eight points.

P.5.9 For the concrete substrate test, cut one control 305mm by 305mm (standard) asphalt specimen into four (small) specimens of approximately 150mm by 150mm in plan. Retain three out of the four small specimens.

P.5.10 For the concrete substrate test, carry out the tensile adhesion test at (20±2)°C in accordance with J.5.3, J.5.5 and J.6 of Appendix J with the control set of three small specimens and with the set of three small concrete substrate specimens.

P.5.11 Carry out the scuffing test in accordance with Appendix G on each remaining set of specimens.

P.6 CALCULATIONS

The changes for the high-friction surface due to the installation temperature, the substrate texture depth or the installation onto a concrete substrate in:

- the final texture depth;
- the loss of texture depth;
- the erosion index; and
- the stress at failure at +20°C (concrete substrate test only)

are the arithmetic differences between the mean values obtained from specimens which have been applied at the extreme temperature, the extreme texture depth or onto a concrete substrate, respectively, and that obtained from specimens which have been applied at 20°C onto an asphalt substrate with a texture depth between 0.9mm - 1.2 mm.

P.7 PRECISION

The precision of the test method has still to be determined.

P.8 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;

b) details of the slabs manufacture including:
   - date and place of manufacture;
   - the material type and specification;
   - the grading and proportion of each aggregate source used;
   - the source, type and grade of the binder and any binder modifier;
   - the temperature at which the slab was manufactured;
   - the texture depth of the substrate; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix A;

c) details of the high-friction surface including:
   - date and place of installation;
   - the high-friction surface system name;
   - the binder and aggregate type;
   - batch numbers for the binder and aggregate;
   - ambient temperature during installation;
   - the mean thickness of high-friction surface on each specimen; and
   - the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) temperature at which the test was carried out;

e) the initial texture depth of each specimen and the mean value for the high-friction surface system;

f) the final texture depth, erosion index and visual observations of each specimen and the mean values for the high-friction surface system when applied at each temperature, texture depth and substrate type;

g) the loss of texture depth for the high-friction surface when applied at the extreme temperature(s) (installation temperature test only);

h) the loss of texture depth for the high-friction surface when applied on substrates at the extreme texture depth(s) (substrate texture depth test only);

i) the loss of texture depth for the high-friction surface when applied at to a concrete substrate (concrete substrate test only);

j) the load at failure at +20°C on each specimen and the mean values and the stress at failure at +20°C on the asphalt and on concrete substrate for the high-friction surface system (concrete substrate test only);

k) the name of the person taking technical responsibility for the test(s);

l) the number of this Appendix, i.e. TRL Report 176, Appendix P;

m) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

P.9 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX Q: TEST PROCEDURE FOR DETERMINATION OF RESISTANCE TO PEELING

Q.1 SCOPE

This Appendix describes the method of test for determining the adhesion between a high-friction surface and the slab to which it is applied when a tensile force is applied perpendicular to the plane of the specimen and the point at which the load is applied advances as the high-friction surface debonds from the surface.

Q.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100.

Q.3 SUMMARY OF TEST METHOD

The high-friction surface system is applied to a slab with strips of mesh below part of the layer. When cured, the specimens are inverted and a gravitational force applied to the ends of the mesh. The load is increased until the mesh pulls the layer of high-friction surface off the slab. The peel-off load is the average load at failure from four determinations.

Q.4 APPARATUS

The apparatus shall consist of the apparatus listed in Appendix C together with:

Q.4.1 *Mesh* of polyester monofilament fibres, each fibre capable of withstanding an axial load of 50N without obvious distress, at a nominal 8 threads per 25mm warp and weft.

Q.4.2 *Aluminium plates*, of nominal dimensions 25mm by 12mm.

Q.4.3 *Cradle* with two horizontal supports 325mm apart, not less than 20mm wide and not less than 600mm long that can support a specimen when loaded with up to 30kg of lead shot.

Q.4.4 *Containers* suitable for holding up to 30kg of lead shot.

Q.4.5 *Fixings* that can pass through the loop formed in a strip of mesh and to which the container can be attached.

Q.4.6 *Lead shot.*

Q.4.7 *Epoxy-resin two-part adhesive.*

Q.5 SAMPLE PREPARATION

Q.5.1 General

Q.5.1.1 Manufacture an asphalt 305mm by 305mm slab of the required material in accordance with Appendix A.

Q.5.1.2 Cut two (25±0.5)mm wide strips of mesh and form loops at each end with aluminium plates, glued either side with epoxy-resin adhesive, as shown in Figure Q.1; the clear length between loops to be not less than 450mm long. Allow to cure for not less than 20 hours before use.

Q.5.1.3 Apply strips of adhesive tape along two opposite sides of the specimen so as to cover (25±5)mm wide bands along both edges. Apply two pairs of strips of adhesive tape perpendicular to first strips so that each pair leaves a (25±1)mm gap, as shown in Figure Q.2.

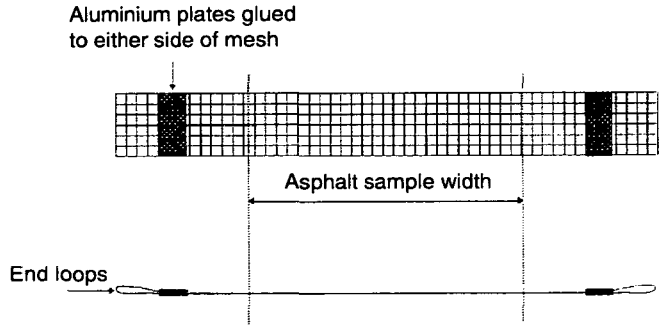

Fig. Q1 Manufacture of loops in Monofilament Polyester mesh

Q.5.1.4 Install the specimen in the cradle with the face to which the high-friction surface is to be applied uppermost. Place two looped strips of mesh on the slab along the gaps left between pairs of strips of adhesive tape (Figure Q.3). Tension the mesh strips by applying a load of (0.5±0.1)kg to each end of the looped strips (Figure Q.4) in order to hold the specimen taught and provide a means of uniformity in specimen manufacture. Fit a set of loading hangers to the end of each loop to facilitate tensioning and specimen loading, as shown in Figure Q.5. Apply the load either by fitting a small container to each loop and filling with lead shot or by the use of ringed weights.

Q.5.2 Chemically Curing Binders

Q.5.2.1 Mix the components of the binder in accordance with the recommendations from the Supplier of the high-friction surface system under test for use on site as far as is practicable. The proportions of any multi-part binder system shall be strictly in accordance with those recommendations; the equipment may need to be adapted to suit the restricted quantities of material required.

Q.5.2.2 Spread the binder uniformly across the mesh on the slab, as shown in Figure Q.4, in accordance with the recommendations from the Supplier of the system under

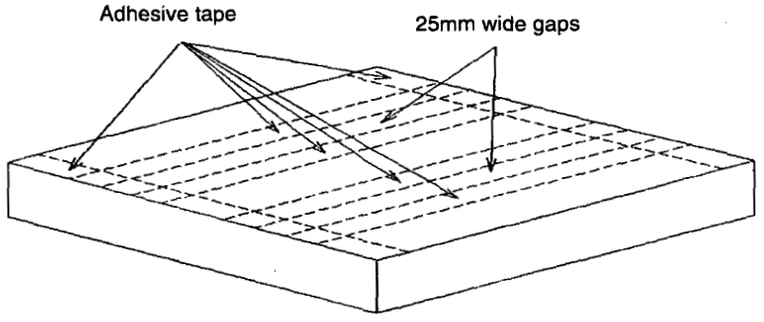

Fig. Q2 Slab preparation for the peel-off test - Application of tape

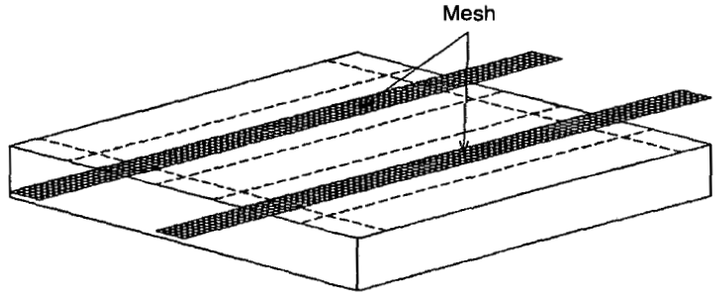

Fig. Q3 Slab preparation for the peel-off test - Positioning of mesh

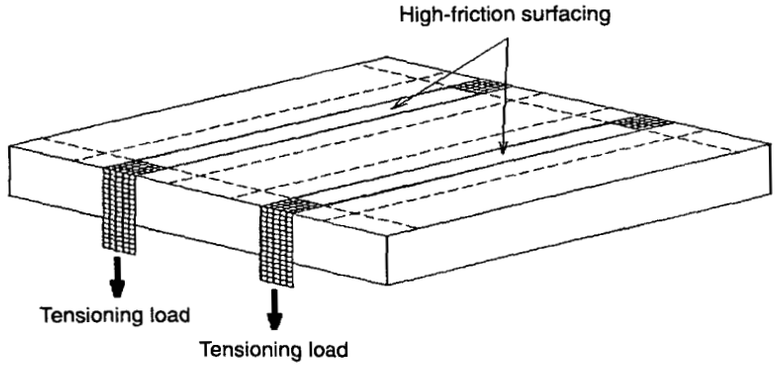

Fig. Q4 Slab preparation for the peel-off test - Application of system

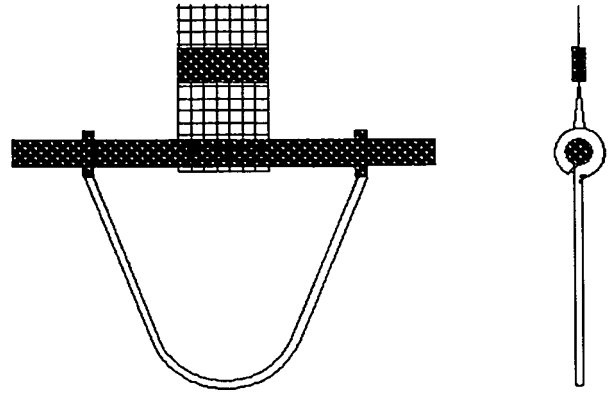

Fig. Q5 Hangers for tensioning and loading of sample

test for use on site as far as practicable. Care is to be taken to ensure that the surface bonds to the slabs through the mesh.

Q.5.2.3 Spread the aggregate uniformly across the slab in accordance with the recommendations from the Supplier of the system under test for use on site as far as practicable.

Q.5.2.4 Allow the surface to cure in accordance with the recommendations from the Supplier of the system under test for use on site as far as practicable.

Q.5.3 Thermoplastic Binders

Q.5.3.1 Heat the pre-mixed system to the required temperature in accordance with the recommendations from the Supplier of the system under test for use on site as far as is practicable.

Q.5.3.2 Spread the system uniformly across the slab, as shown in Figure Q.4, in accordance with the recommendations from the Supplier of the system under test for use on site as far as practicable. Care is to be taken to ensure that the surface bonds to the slabs through the mesh.

Q.5.3.3 Allow the surface to cool in accordance with the recommendations from the Supplier of the system under test for use on site as far as practicable.

Q.6 PROCEDURE

Q.6.1 Once the surface has cured (chemically curing systems) or cooled (thermoplastic systems) sufficiently to remain without flowing, detach the tensioning loads and carefully remove the adhesive tape, together with any surface overlying it. If necessary, cut along the sides of the strips of surface so that no additional material is adhering to both the slab and the mesh beyond the 25mm wide strip.

Q.6.2 (24±4) hours after applying the surface to the slab, turn the specimen over so that the surface faces downwards and place it onto the cradle so that the supports are not located below areas covered by mesh and surface. Suspend the container from the loop at the free end of a strip of mesh.

Q.6.3 Pour lead shot at a regular rate into the container up to the moment when a slow and regular peeling takes place over a length of at least 10mm. Remove the loaded container and weigh to the nearest 1g. Note the mode of failure in terms of loss of cohesion within the slab, loss of adhesion between the slab and resin or loss of cohesion within the resin.

Q.6.4 Repeat Q.6.2 and Q.6.3 with the container attached to each loop at the free end of each strip of mesh in turn.

Q.7 CALCULATIONS

Q.7.1 The peel-off load is the mean of the weight of the container plus lead shot on each strip end when peeling occurred.

Q.7.2 The mode of failure is the common mode of failure for at least three determinations; if no mode occurs three times, then the mode of failure is indeterminate.

Q.8 PRECISION

The precision of the test method has still to be determined.

Q.9 REPORTING OF RESULTS

The test report shall include the following information:

a) date, time and place of test;
b) details of the slabs manufacture including:
   - date and place of manufacture;
   - the material type and specification;

- the grading and proportion of each aggregate source used;
- the source, type and grade of the binder and any binder modifier;
- the temperature at which the slab was manufactured;
- the texture depth of the substrate; and
- the number of the Appendix, i.e. TRL Report 176, Appendix A;

c) details of the high-friction surface including:
- the high-friction surface system name;
- the binder and aggregate type;
- batch numbers for the binder and aggregate;
- ambient temperature during installation; and
- the number of the Appendix, i.e. TRL Report 176, Appendix C;

d) period for which the resin had cured at the time of testing;

e) temperature at which the test was carried out;

f) the loads at which the four individual mesh peeled from the slab;

g) the peel-off load;

h) the mode of failure that occurred;

i) the name of the person taking technical responsibility for the test;

j) the number of this Appendix, i.e. TRL Report 176, Appendix Q;

k) any test conditions and operational details not provided in this Appendix, and anomalies, if any, likely to have affected the results.

Q.10 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part 100. Methods for sampling for analysis. *BS 598: Part 100: 1987.* British Standards Institution, London.

APPENDIX R: PROCEDURE FOR VISUAL ASSESSMENT OF TRIAL SITES

R.1 SCOPE

This Appendix describes a general procedure for visually assessing the condition of trial sites. In the particular case of high-friction surface systems, this assessment can assist in confirming the results from laboratory tests in terms of overall durability.

R.2 DEFINITIONS

For the purposes of this Appendix, the definitions given in BS 598: Part 100 apply together with the following:

R.2.1 A *site* is a length of highway open to regular traffic on which one or more surfacing materials, component materials or construction techniques has been laid in order to assess their (comparative) performance in service.

R.2.2 A *section* is a distinct length of a site on which one distinct surfacing material, component material or construction technique has been laid.

R.2.3 *Control section* is a section of a site that employs existing, conventional materials and techniques of surfacing and is included when comparative performance is required.

R.3 SELECTION OF SITES

The Convenor, in consultation with colleagues as appropriate, shall be responsible for the selection of sites to be inspected. He/she shall, as far as is practicable, ensure that different sections on selected sites were laid at approximately the same time under similar conditions and without factors that may excessively bias the comparative results from what will occur on typical sites in this country.

R.4 INSPECTION PANEL

R.4.1 The Inspection Panel shall consist of a Convenor and between four and seven other members who have experience of road surfaces and, in particular, the type of surfacings to be inspected. The majority of the members should be regular members who regularly attend the site inspections.

R.4.2 The Convenor, after fixing the date for an inspection, shall inform other members as soon as possible but not less than a month before the inspection. A copy of this procedure for inspecting road trial sites shall be sent to any potential panel members who have not taken part before so that they can familiarise themselves with it. Members shall let the Convenor know if they are unable to attend and, if less than five members can take part, the Convenor shall try to re-arrange the date for the convenience of members.

R.4.3 The Convenor shall be responsible for arranging any road closures or other precautions necessary to ensure that the inspection can be carried out in a safe and orderly manner. All Panel Members shall wear reflective jackets during an inspection.

R.5 INITIAL PROJECT BRIEFING

Once the Inspection Panel has assembled, members shall be given an Inspection Panel Member's Report Form. The Convenor shall have an Inspection Panel Convenor's

Report Form in addition to his/her Inspection Panel Member's Report Form. If appropriate, the Convenor shall brief members on particular aims of the trial and any implications on the emphasis of that inspection.

R.6 INSPECTION

R.6.1 The Panel shall agree on the weather conditions prevailing, and record it on their report forms.

R.6.2 The Panel shall walk each section in turn, studying the condition as closely as practicable. Members shall stop and look back at intervals along each section so as to view the surfacing with the light in a different direction.

R.6.3 Any portion at one end of a machine-laid section which has a slightly different appearance from the rest of the section shall be ignored by the Panel. Similarly, localised areas that have been subject to untypical mechanical or chemical actions (e.g. damage caused by a vehicle running on its wheel-rim or by a major diesel spillage) shall also be ignored. If variations are on a larger scale, such as between wagon loads when laid, the section shall be assessed in subsections. The Convenor shall try to establish the reasons for any large differences by checking the laying records and, where appropriate, the compositional analysis at the appropriate time.

R.6.4 Members shall record on their Inspection Panel Member's Report Form a mark for each section or subsection soon after inspecting it. Whilst members can discuss points of interest noted during the inspection, they shall not reveal their marking until all members have recorded their individual mark.

R.7 MARKING

R.7.1 Each section or sub-section shall be assessed on the basis of its current serviceability irrespective of the elapsed time since it was laid. In considering the serviceability of the surfacing, the aspects in Table R.1 for the specific type of surfacing shall be considered, together with any project related aspects given in the initial briefing. If any of the aspects are evident to a significant degree on the section, the relevant suffix from Table R.1 shall be applied to the basic marking. Suffix *v* shall not be applied to a section marked as *t*, nor + to one marked -.

R.7.2 Once any appropriate fault suffixes have been assigned, the basic mark shall be allocated from the 7-point scale in Table R.2. Intermediate markings between scales shall not be given. When considering the markings, any sections that warrant a suffix cannot have a basic mark of *G* or better.

R.8 OVERALL ASSESSMENT

R.8.1 When each member has reported his individual result, the Convenor shall convert each mark to an arithmetic value using the transformation:

$E \rightarrow 6$; $G \rightarrow 5$; $M \rightarrow 4$; $A \rightarrow 3$; $S \rightarrow 2$; $P \rightarrow 1$; and $B \rightarrow 0$.

The mean of the individual arithmetic values shall be calculated to one decimal place and converted back into the Panel marking using the transformation:

5.8 to 6.0 → *E*;	5.3 to 5.7 → *E/G*;	4.8 to 5.2 → *G*;
4.3 to 4.7 → *G/M*;	3.8 to 4.2 → *M*;	3.3 to 3.7 → *M/A*;
2.8 to 3.2 → *A*;	2.3 to 2.7 → *A/S*;	1.8 to 2.2 → *S*;
1.3 to 1.7 → *S/P*;	0.8 to 1.2 → *P*;	0.3 to 0.7 → *P/B*;
and	0.0 to 0.2 → *B*.	

R.8.2 Suffixes shall be applied to the Panel marking when at least a third of the Panel members, rounded up, give it on their individual markings provided:

- the basic Panel marking is not *G* or better, as then no suffixes can be applied; and
- both *v* and *t*, or both + and -, are given, when only one of each pair can be applied to the basic Panel marking. The choice shall be based on the number of times the different suffixes occur on individual markings (in the case of a tie, the Convenor shall decide).

R.8.3 If the Panel consists of less than 6 members at an inspection, this fact shall be noted when reporting the results.

R.9 CONFIDENTIALITY

Whilst the Panel marking can be reported, the individual marks allocated by members of the Panel shall be treated in confidence. This is to allow members to make judgements as to the condition of the trial sections without consideration of the commercial interests of their organisation.

R.10 PRECISION

The precision of the test method has still to be determined.

TABLE R.1

Fault Suffixes

Suffix	Description	Material type	Notes
v	variable	all	Random variations from point to point within the section only, not "traffic laning" or of obvious variations from load to load.
t	variability with traffic intensity	all	Marked transverse differences caused by variations in traffic intensity between lanes.
+	fatting up	macadam, stone mastic asphalt, surface dressing, high-friction surfaces	
-	loss of chippings	rolled asphalt	
	loss of aggregate	porous asphalt, macadam, stone mastic asphalt, thin surfacings, high-friction surfaces, slurry surfacing	
	loose aggregate	surface dressing	
f	fretting of mortar	rolled asphalt	
g	growth of vegetation	porous asphalt	
p	ponding	porous asphalt	
d	de-lamination from substrate	porous asphalt, thin surfacings, surface dressing, high-friction surfaces, slurry surfacing	
s	stripping	all except high-friction surfaces	
c	cracking	rolled asphalt, macadam, stone mastic asphalt, thin surfacing, high-friction surfaces	
w	wear with aggregate from substrate "grinning" through	thin surfacings, surface dressing, high-friction surfaces, slurry surfacing	

TABLE R.2

Basic 7-Point Scale

Mark	Description	
E (excellent)	no discernable fault	Termed satisfactory
G (good)	no significant fault	Termed satisfactory
M (moderate)	some faults but insufficient for serious problem	Termed satisfactory
A (acceptable)	several faults but would usually be just acceptable	Termed satisfactory
S (suspect)	seriously faulted but still serviceable in the short term	Termed unsatisfactory
P (poor)	requires remedial treatment	Termed unsatisfactory
B (bad)	requires immediate remedial treatment	Termed unsatisfactory

R.11 REPORTING OF RESULTS

The inspection report shall include the following information:

a) date, time and location of the inspection;

b) number of people in the Inspection Panel present;

c) prevailing weather conditions;

d) sufficient details of each section inspected to allow unique identification;

e) basic Panel marking with any associated fault suffixes for each section inspected; and

f) any comments about the site(s) not otherwise covered.

R.12 REFERENCES

BRITISH STANDARDS INSTITUTION (1987). Sampling and examination of bituminous mixtures for roads and other paved areas, Part100. Methods for sampling for analysis. *BS 598: Part 100: 1987*. British Standards Institution, London.

MORE INFORMATION

The Transport Research Laboratory has published the following other reports on this area of research:

PR12 The testing and performance of surface dressing binders for heavily trafficked roads. J Carswell. Price code E.

PR79 Road trials of thin wearing course materials. J C Nicholls, J F Potter, J Carswell and P Langdale. Price code H.

RN39 Design Guide for road surface dressing. J C Nicholls. Price Code J.

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