Transport Scotland
Executive Agency of the Scottish Government
Roads (Standards and Asset Management)

Summary

This Interim Amendment contains the updated Specification for Surface Course TS2010, intended for use on the trunk road network in Scotland.

1. Background

Transport Scotland first published TSIA 35 in 2010 following a research project which worked closely with the industry supply chain to reconfigure the SMA specification. The study was in response to repeated examples of shorter than anticipated service life from various proprietary Thin Surface Course Systems (TSCS) and generic Stone Mastic Asphalts (SMA). The Specification seeks to provide a more durable surface course material and to improve quality control during the implementation phase. This Interim Amendment implements the 4th edition of the TS2010 specification as part of the ongoing aim to review and improved the specification.

2. Action

TS2010 continues to be a permitted surface course material on both new build and maintenance schemes on the trunk road network in Scotland, where specified in tender documents. TS2010: Specification and Guidance Issue 04 (November 2018) replaces TS2010 Issue 03 (April 2015) and is included as Appendix A.

3. Implementation

This TSIA shall be implemented immediately except where the procurement of works, at any stage from conception through design to completion of construction, has reached a stage at which, in the opinion of the TS Project Manager, use of this document would result in significant additional expense or delay progress.

4. Further action

Any questions or feedback regarding the use or content of this TSIA should be directed to Transport Scotland: info@transport.gov.scot.

Appendix A

TS2010 4th Edition (November 2018)

TS2010

Surface Course Specification & Guidance

Issue 04 (November 2018)

Transport Scotland
Buchanan House
58 Port Dundas Road
Glasgow G4 0HF

Contents

1 Introduction

Historically, as a consequence of problems with the quality and in-service performance of Stone Mastic Asphalt (SMA), Transport Scotland worked closely with the industry to adjust and develop materials approved for use on the trunk road network and to enhance quality control.

In parallel with this work, TRL were commissioned to undertake a programme of research to identify best practice among countries with similar climatic conditions to Scotland. It quickly became apparent that Germany was producing a family of SMAs that were reliable, durable and able to be consistently manufactured, and, as a result, research became concentrated on that country's specifications and methodologies.

This TS2010 specification and guidance is based on research allied to the findings of study visits to Germany, during which first-hand knowledge of German specifications, best practice and experience was gained. Subsequently, the specification developed was used in Scottish road trials and carefully monitored.

Notwithstanding the above, however, any intrinsically new specification requires controlled introduction and fine tuning. The ongoing development of TS2010 continues to be undertaken progressively and in collaboration with UK industry practitioners.

Transport Scotland and TRL are grateful to the German road authorities, both at local and state levels, and to the German academics and practitioners who all freely assisted with their time and knowledge. Grateful thanks are also due to our own industry for enthusiastically supporting the trialling and embracing the development of the TS2010 initiative.

1.1 TS2010 Surface Course

The TS2010 surface course specification comprises a range of SMA mixtures that are based on German specifications and experience. The SMA mixtures will contain a gap-graded aggregate mix, polymer modified bitumen, and additives, including fibres. The newly-laid SMA will be treated with grit to increase the early-life skid resistance.

The decision to develop this specification for use in Scotland has been based on its proven track record in Germany.

Research has indicated that it can provide the following benefits:

- superior durability
- lower noise levels
- good skid resistance, including early-life
- high resistance to permanent deformation
- decreased life-time costs
- thin layer application
- excellent ride quality
- reduced use of expensive imported aggregates
- increased use of a wider range of sustainable aggregate sources.

1.2 Relationship to Overseeing Organisation National Manuals

CD236 (DMRB 7.5.1) Surfacing for New and Maintenance Construction, sets out the permitted pavement surfacing material requirements. A Transport Scotland National Application Annex sets out detailed requirements for the Scottish Trunk Road Network. This is issued as a Transport Scotland Interim Amendment TSIA 50 (www.transport.gov.scot/transport-network/roads/design-of-trunk-roads/#).

1.3 Specification with Notes for Guidance

This specification (TS2010) was drafted in accordance with PD 6691 and is based on the European Standard for SMA, BS EN 13108-5. The notes for guidance give more advice on the background to the specifications, testing and other best practice approaches to quality control.

2 TS2010 Stone Mastic Asphalt Surface Course - Specification

2.1 General

The SMA described within this specification (TS2010) conforms to BS EN 13108-5 where applicable. Such conformity shall be established in accordance with BS EN 13108-20 and BS EN 13108-21.

Specification clause references within this document are included without a prefix (e.g. 2.2.2.1). Notes for Guidance clauses are prefixed by NG (e.g. NG 2.2.5). References relating to other standards and specifications in all cases include reference to the associated source documentation.

Normative and informative reference documents, such as British Standards, European Standards, UK Overseeing Organisations' publications, etc., to which reference is made in this specification relate to the most recent published edition unless otherwise stated.

The requirements of Clauses 901 and 903 of the Specification for Highway Works apply and the 'Surfacing Integrity - Performance Guarantee' shall be in accordance with paragraphs 24 and 25 of Highways Agency Interim Advice Note 154.

Where references and text relate to ENs and other European Standards and Specifications, a comma is used to denote the decimal separator, in accordance with standard European practice.

It should be noted at the outset that this specification requires an increased level of data reporting which is not related to compliance with specific limits. This is to assist future development of the material.

2.2 Constituent Materials

2.2.1 Binder

The binder shall be 75/130-75 polymer modified binder conforming to BS EN 14023. Compliance and test data for the binder proposed shall be included as part of the Type Approval Installation Trial (TAIT), Stage 1 requirements (see Table 2.6, NG 2.2.1 and Table NG 2.1).

2.2.2 Aggregate

2.2.2.1 *Coarse aggregates*

The coarse aggregate used in the SMA shall be material substantially retained on a 2 mm test sieve, conforming to all appropriate requirements of BS EN 13043 and consisting of either crushed rock or crushed gravel of one or more of the following groups: basalt, gabbro, granite, gritstone, hornfels, porphyry or quartzite. Aggregates outwith these rock types that can demonstrate a history of successful use as a thin surfacing aggregate may also be proposed.

2.2.2.1.1 Particle density

The particle density shall be determined in accordance with BS EN 1097-6, Clause 8 or 9, depending upon the size of the aggregate, and the results declared.

2.2.2.1.2 Particle shape

The flakiness index for the coarse aggregates shall be FI_{20} (see NG 2.2.2.1.2).

2.2.2.1.3 Fines content

The fines content category for the coarse aggregate shall be f_4.

2.2.2.1.4 Resistance to polishing

The polished stone value category for the coarse aggregate shall be declared (see NG 2.2.2.1.4).

2.2.2.1.5 Resistance to fragmentation

The resistance to fragmentation for coarse aggregates shall be LA_{30}.

2.2.2.1.6 Resistance to surface abrasion

The resistance to surface abrasion for the coarse aggregate shall be AAV_{12}.

2.2.2.1.7 Resistance to wear

The resistance to wear for the coarse aggregate shall be $M_{DE\ declared}$.

2.2.2.2 *Fine aggregate*

The fine aggregate used in the SMA shall substantially pass a 2 mm test sieve and be a crushed material from one or more of the groups specified in 2.2.2.1.

2.2.2.2.1 Fines content

The fines content category for fine aggregate shall be f_{22}.

2.2.3 Added filler

2.2.3.1 *Type of added filler*

All added filler used in the SMA shall be limestone and shall comply with the grading of BS EN 13043, Clause 4.3.6. Notwithstanding this, hydrated lime may be added up to a maximum of 2% by mass of the aggregate.

2.2.3.2 Bulk density

The loose bulk density in kerosene of added filler, with the exception of hydrated lime, shall be in accordance with BS EN 13043, Clause 5.5.5.

2.2.4 Recycled material

2.2.4.1 *Aggregate*

Any recycled aggregate used in the SMA shall comply with 2.2.2.

2.2.4.2 *Reclaimed asphalt*

The use of reclaimed asphalt is not permitted (see NG 2.2.4.2).

2.2.5 Additives

Fibres are a required additive and shall be in pelleted form, either wax-coated or bitumen coated. The SMA mixtures shall include a minimum fibre content of 0,3% by mass (see NG 2.2.5).

Other additives which may be permitted for inclusion are special fillers, adhesion and workability agents. The suitability of any additives to be used shall be demonstrated in accordance with BS EN 13108-5, Clause 4.1.

2.3 Composition

2.3.1 Grading and binder content

The grading of the composition of the SMA shall conform to the relevant column of Table 2.1A or Table 2.1B. Grading envelopes are given in Figure 2.1 to Figure 2.4. The supplier is required to choose targets that comply with the grading limits given in Table 2.1A and Table 2.1B. Tolerances specified in BS EN 13108-21 will be applied to the target grading.

The tolerance applying to the minimum target binder contents (B_{act}) in Table 2.1A or Table 2.1B shall be ±0,20% by mass (see NG 2.3). This compliance criterion shall be applied to a rolling mean of the analyses of four samples to determine binder content in accordance with BS EN 12697-1.

Table 2.1A: Limits for composition of the SMA mixtures b)

***D* (mm)**	**6**	**10**	**14**
Sieve	**Proportion passing sieve (% by mass)**		
20	–	–	100
14	–	100	93 – 100
10	100	93 – 100	35 – 60
6,3	93 – 100	35 – 52	22 – 36
4	35 – 52	–	–
2	25 – 35	20 – 32	16 – 30
0,5 a)	–	–	–
0,25 a)	–	–	–
0,063	8 – 14	8 – 12	8 – 12
Minimum target binder content B_{act} (% by mass)	7,1	6,7	6,3

a) The producer will state the target % passing for the 0,5 mm and 0,25 mm sieves and the tolerance stated in BS EN 13108-21 will be applied to this target to ensure consistency.
b) The SMA mixtures shall include a minimum fibre content of 0,3% by mass (see NG 2.2.5).

Table 2.1B: Limits for composition of the SMA mixtures b)

***D* (mm)**	**(8)***
Sieve	**Proportion passing sieve (% by mass)**
16	–
11,2	(100)*
8	(93 – 100)*
5,6	(35 – 55)*
2	(20 – 32)*
0,71 a)	–
0,125 a)	–
0,063	(8 – 12)*
Minimum target binder content B_{act} (% by mass)	(6,9)*

*See NG 2.3.1

a) The producer will state the target % passing for the 0,71 mm and 0,125 mm sieves and the tolerance stated in BS EN 13108-21 will be applied to this target to ensure consistency.

b) The SMA mixtures shall include a minimum fibre content of 0,3% by mass (see NG 2.2.5).

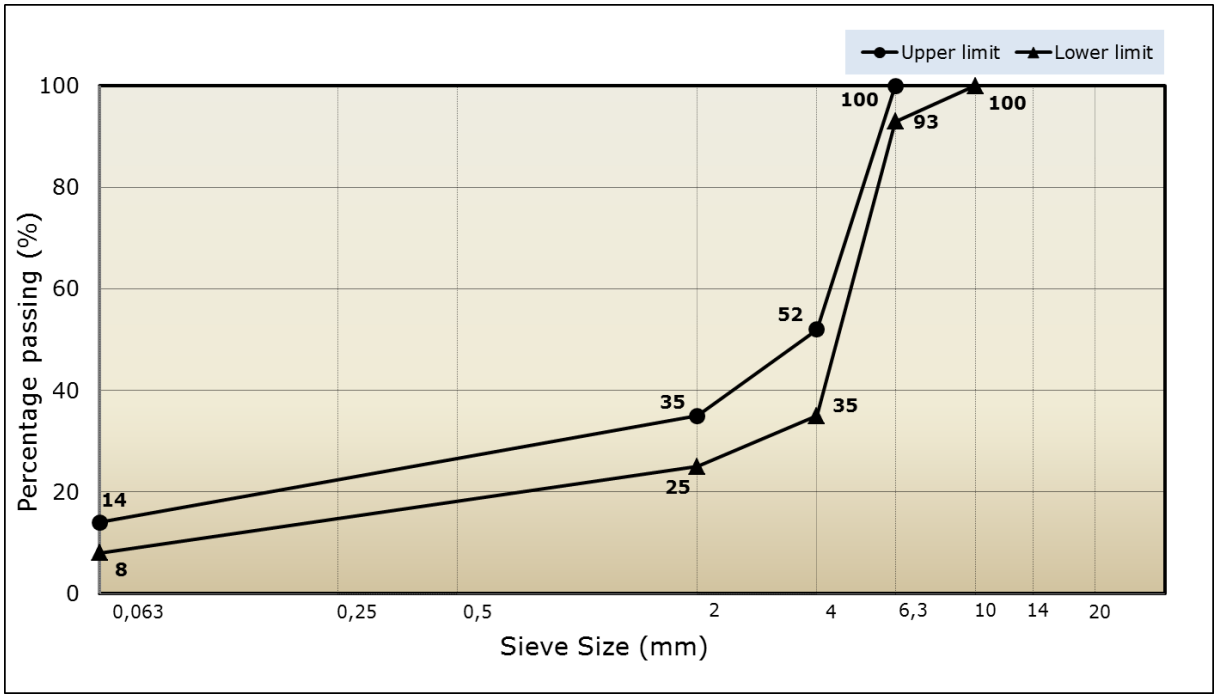
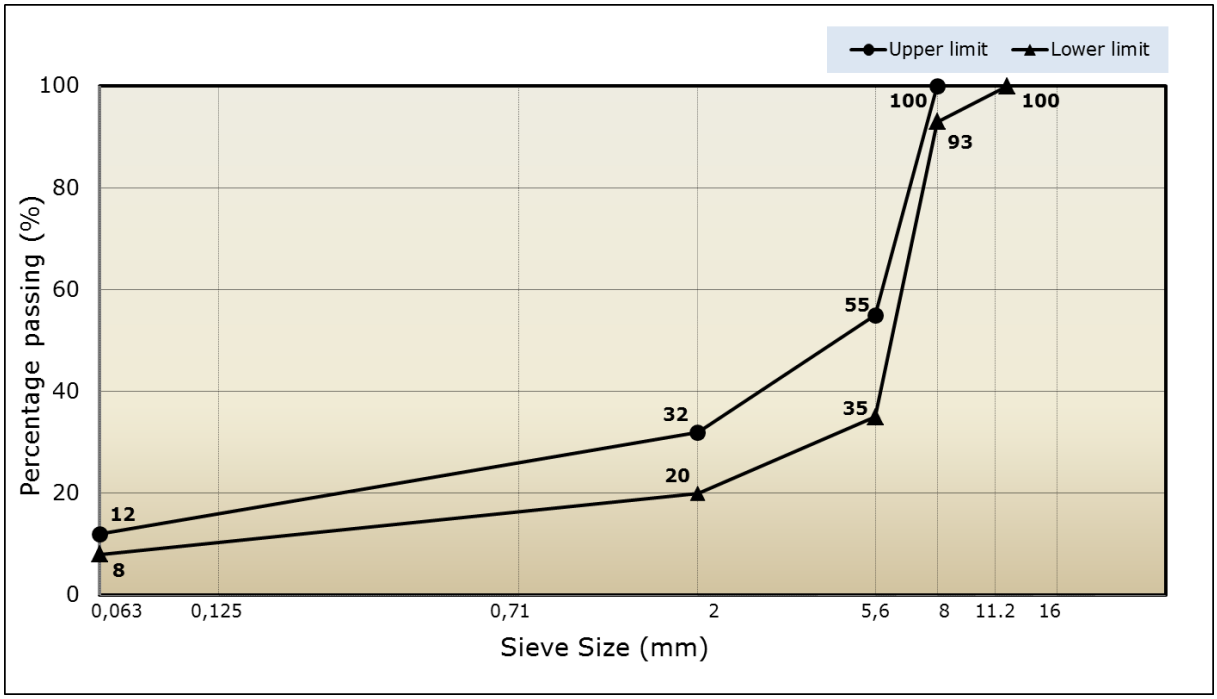


Figure 2.1: SMA 6 (surf)



*See NG 2.3.1

Figure 2.2: (SMA 8 (surf))*

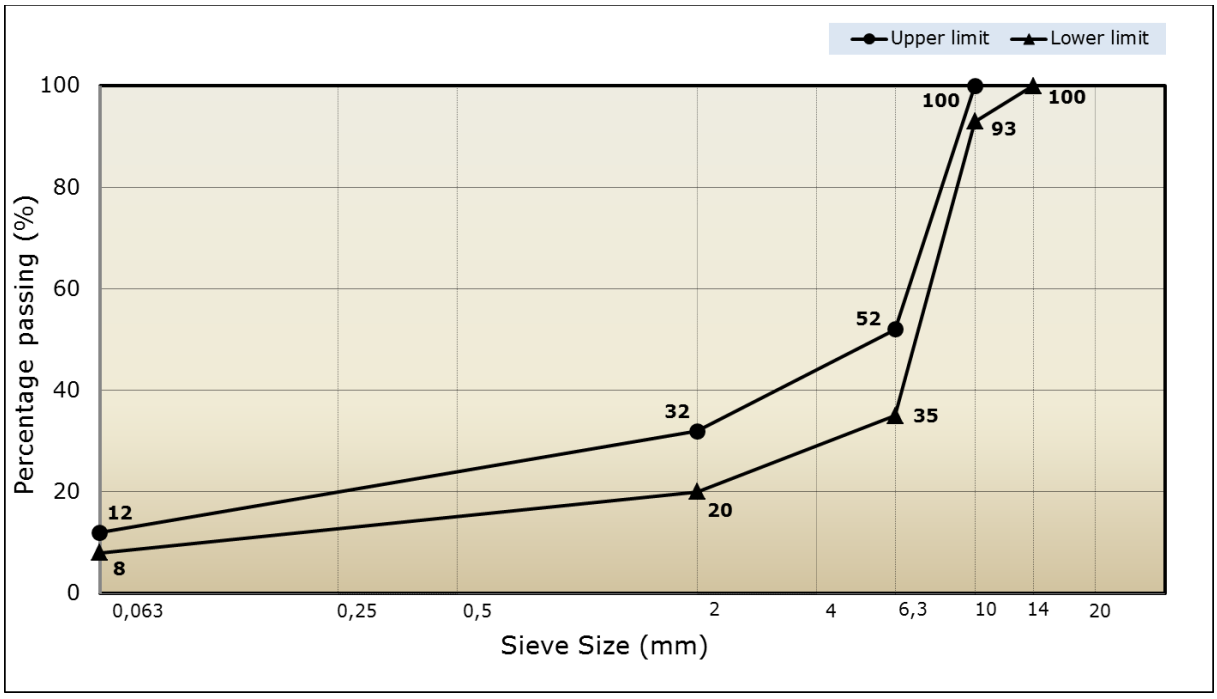


Figure 2.3: SMA 10 (surf)

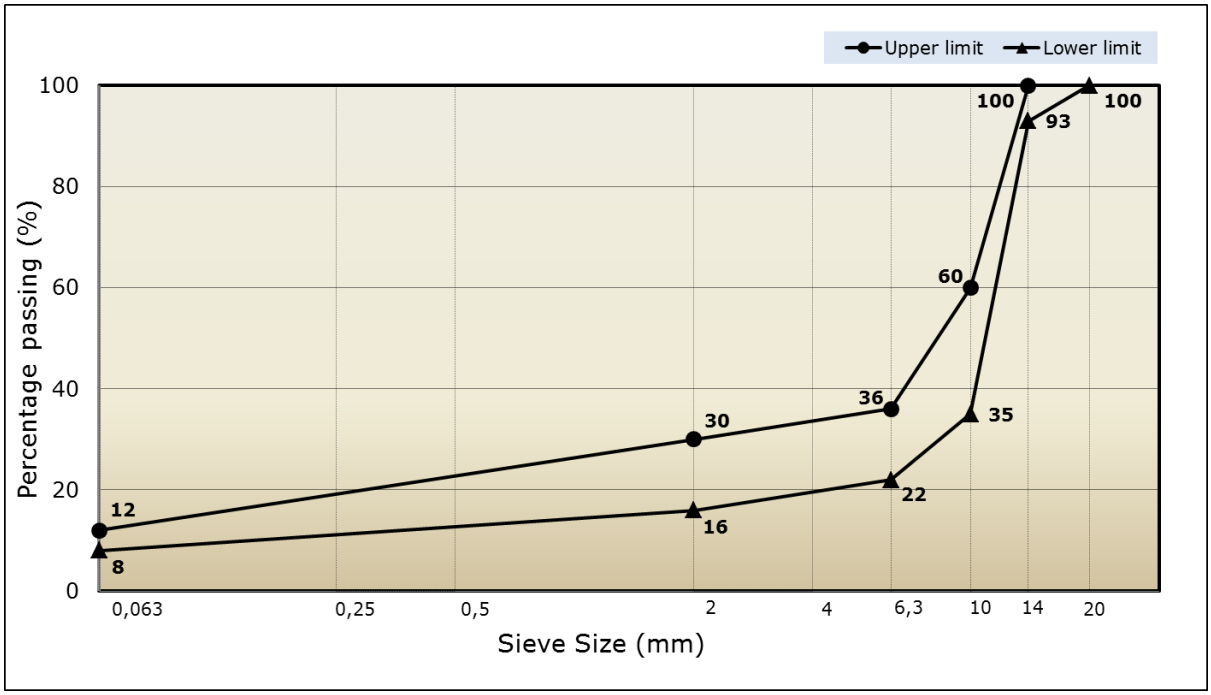


Figure 2.4: SMA 14 (surf)

2.4 Air Voids Content

2.4.1 Laid and compacted mat

The air void content of the laid and compacted material shall be continuously assessed using an indirect density gauge in accordance with BS594987, Annex I, with readings taken at 20m intervals in alternative wheel-tracks (see NG 2.4.2). Average air voids results shall be as follows:

a) The average void content category for SMA 6 (surf) or SMA 8 (surf) of a set of indirect density gauge readings shall be: V_{min2}; V_{max6}.
b) The average void content category for SMA 10 (surf) or SMA 14 (surf) of a set of indirect density gauge readings shall be: V_{min2}; V_{max5}.

2.4.1.1 *Surface course thickness*

The thickness of the laid surface course shall conform to the relevant column of Table 2.2 (see NG 2.4.2.1).

Table 2.2: Laid thickness

Mixture description	Thickness range (mm)	Minimum thickness at any one point (mm)
SMA 6	20 - 40	15
SMA 8	25 - 40	20
SMA 10	25 - 50	20
SMA 14	35 - 60	30

2.5 Binder Drainage

The average binder drainage category of a set of specimens tested in accordance with BS EN 12697-18, Clause 5 (Beaker method), shall be $D_{0,3}$ (see NG 2.5).

2.6 Water Sensitivity

The water sensitivity category shall be $ITSR_{NR}$ (see NG 2.6).

2.7 Resistance to Permanent Deformation

The resistance to permanent deformation of samples at target composition taken in accordance with BS 594987, Annex G, shall be determined in accordance with BS EN 12697-22 using the small device and Procedure B in air at a test temperature of 60 ºC. The resistance to permanent deformation shall be WTS_{AIR1}.

2.8 Temperature of the Mixture

In all cases where mixtures are produced, mixing temperatures shall be documented and declared. Guidance on minimum temperatures at delivery and for compaction is found in BS 594987.

2.9 Grit for Application to Surface Course

2.9.1 General

For specification purposes, grit shall be considered as a mixture and evaluation of conformity determined in accordance with BS EN 13108-20 and BS EN 13108-21 (see NG 2.9).

2.9.2 Material

2.9.2.1 *Type of grit*

Grit shall be coarse aggregate conforming to 2.2.2.1.

2.9.2.2 *Grading*

The grading of grit shall be as in the relevant column of Table 2.3.

2.9.2.3 *Binder content*

The binder used to coat the grit shall be 40/60 grade conforming to BS EN 12591. The tolerance on the target binder content as shown in Table 2.3 shall be ± 0,5%.

Table 2.3: Composition of grit mixture

Test Sieve (mm)	Proportion passing test sieve (% by mass)	
	2/4 particle size	1/2,8 particle size
8	–	–
6,3	100	–
4	90 – 100	100
2,8	–	90 – 100
2	0 – 35	–
1	–	0 – 25
0,063	0 – 2	0 – 2
Target binder content (%)	0,7	1

2.9.2.4 *Condition of coated grit on application*

The coated grit shall be free-flowing and free from agglomerations or bunching.

2.9.2.5 *Assessment and verification of constancy of performance*

The assessment and verification of constancy of performance shall be carried out in accordance with BS EN 13108-4, Clause 6.

2.9.3 Application

2.9.3.1 *General*

The grit shall be machine-applied in such a manner as to achieve a uniform distribution of between 0,75 and 1,25 kg/m^2.

2.9.3.2 *Application of grit*

The grit shall be applied from hoppers attached to a roller immediately after compaction by the paver screed or one pass of the roller. The rolling pattern shall, as far as practicable, provide a single application of grit to the full width with no overlap. Gritting should be carried out on hard shoulders but is not required on other areas that will not be trafficked (e.g. hard strips or chevron areas) however it may not be practicable to avoid gritting these areas (see NG 2.9.3).

2.9.3.3 *Sweeping*

When the material has reached ambient temperature, any surplus grit shall be removed carefully by mechanical brushing prior to the application of road markings and before the road is opened to traffic. Subsequent sweeping may be required after trafficking.

2.10 Skid Resistance

2.10.1 Early-life skid resistance

2.10.1.1 *Compliance requirements*

The surface skid resistance shall be measured using the GripTester braked-wheel fixed-slip device in accordance with BS 7941-2, or equivalent device possessing appropriate validation. Tests and reporting shall be undertaken in accordance with the operating procedure described in TSIA 49 at four weeks and six months after opening to traffic.

The 10 m rolling-average GripNumber shall be compared against the values given in Table 2.4. Where any four-week 10 m rolling-average GripNumber does not achieve the appropriate value in Table 2.4, this shall be reported to the Overseeing Organisation and no rectification shall be required due to these results alone. Where any 10 m rolling-average GripNumber does not achieve the appropriate value in Table 2.4 after 6 months of trafficking, rectification shall be undertaken in accordance with Clause 2.10.1.2 (see NG 2.10).

Table 2.4: Minimum GripNumber (50 km/h)

Site Class	HD 28 Site Category[a)]	Minimum 10 m rolling-average GN
1	A, B & C	0.39
2	R, G1 & S1	0.51
3	Q, K, G2 & S2	0.56

a) Table 4.1 of HD28 (DMRB 7.3.1)

2.10.1.2 *Rectification*

Where any 10 m rolling-average GripNumber, or sequence of them, does not achieve the minimum values in Table 2.4 after six months of trafficking, the full extent of this area plus 10m either side shall be made good by removing and replacing the full depth of the surface course. This shall be carried out over the full width of the lane with fresh material laid and compacted in accordance with this specification. Where such remedial patches are within 20m of each other they shall be combined into a single patch.

2.11 Texture

The surface course shall exhibit a uniform macrotexture. Although there are no specification requirements for texture depth, such measurements are required to be taken and reported (see NG 2.11).

2.12 Type Approval Installation Trial (TAIT)

2.12.1 Fundamental requirement

The producer shall undertake the Type Approval Installation Trial (TAIT) process set out below for each variant of the TS2010 material. Any change to any of the constituent materials, the production plant or surfacing contractor is considered to be a variant (see NG 2.12).

2.12.2 General requirements

2.12.2.1 *TAIT process*

The TAIT takes the form of a three-stage process, as shown within Figure 2.5 and listed in Table 2.6, Table 2.7 and Table 2.8. Each stage of the TAIT must be approved by Transport Scotland before progression to the next Stage. Stage 1 and Stage 2 (i.e. Table 2.6 and Table 2.7) follow the requirements of BS EN 13108 with the addition of certain other necessary tests. The purpose of the TAIT is to demonstrate that the product is able to be consistently produced in accordance with the requirements of this specification, and that it demonstrates the necessary properties. The grading of the mixture and that of the grit shall comply with the relevant column of Table 2.1A or Table 2.1B and Table 2.3 of this document.

The producer shall design and construct the surfacing, of which the TAIT is a representative section, in accordance with documented Factory Production Control System in BS EN 13108-21. The producer shall record all the data required by these documents and any additional information required by Transport Scotland.

2.12.2.1 *Relaxation on Stage 1 requirements for alternative surfacing contractor*

Approval to lay a Transport Scotland approved TS2010 mixture with an alternative surfacing contractor is subject to evidence that the alternative surfacing contractor can demonstrate completion of a satisfactory Stage 2 and Stage 3 of an approved TS2010 mix.

2.12.2.2 *Relaxation on Stage 2 requirement for alternative plant*

Notwithstanding the requirements listed in 2.12.2.1 above, where a TS2010 product proposal has achieved Approval by Transport Scotland (through laboratory study, product mix trial and Trunk Road Network Trial) approval to supply that product from an additional or alternative asphalt production plant shall be subject to submission of satisfactory plant information and binder content and grading from trial batching. The requirements are listed in Table 2.9.

2.12.3 GripNumbers – Classification requirements

The 10 m rolling-average GripNumber shall be recorded and compared to the values given in Table 2.5.

Table 2.5: Mean GripNumber (50 km/h)

Site Class	HD 28 Site Category[a)]	Minimum 10 m rolling-average GripNumber	
		After 4 weeks trafficking	After 6 months trafficking[b)]
1	A, B & C	0.39	0.56
2	R, G1 & S1	0.51	0.62
3	Q, K, G2 & S2	0.56	0.67

a) Table 4.1 of HD28 (DMRB 7.3.1)
b) Approval for Site Class 2 & 3 can only be obtained where the Stage 3 has been carried out on that Site Class.

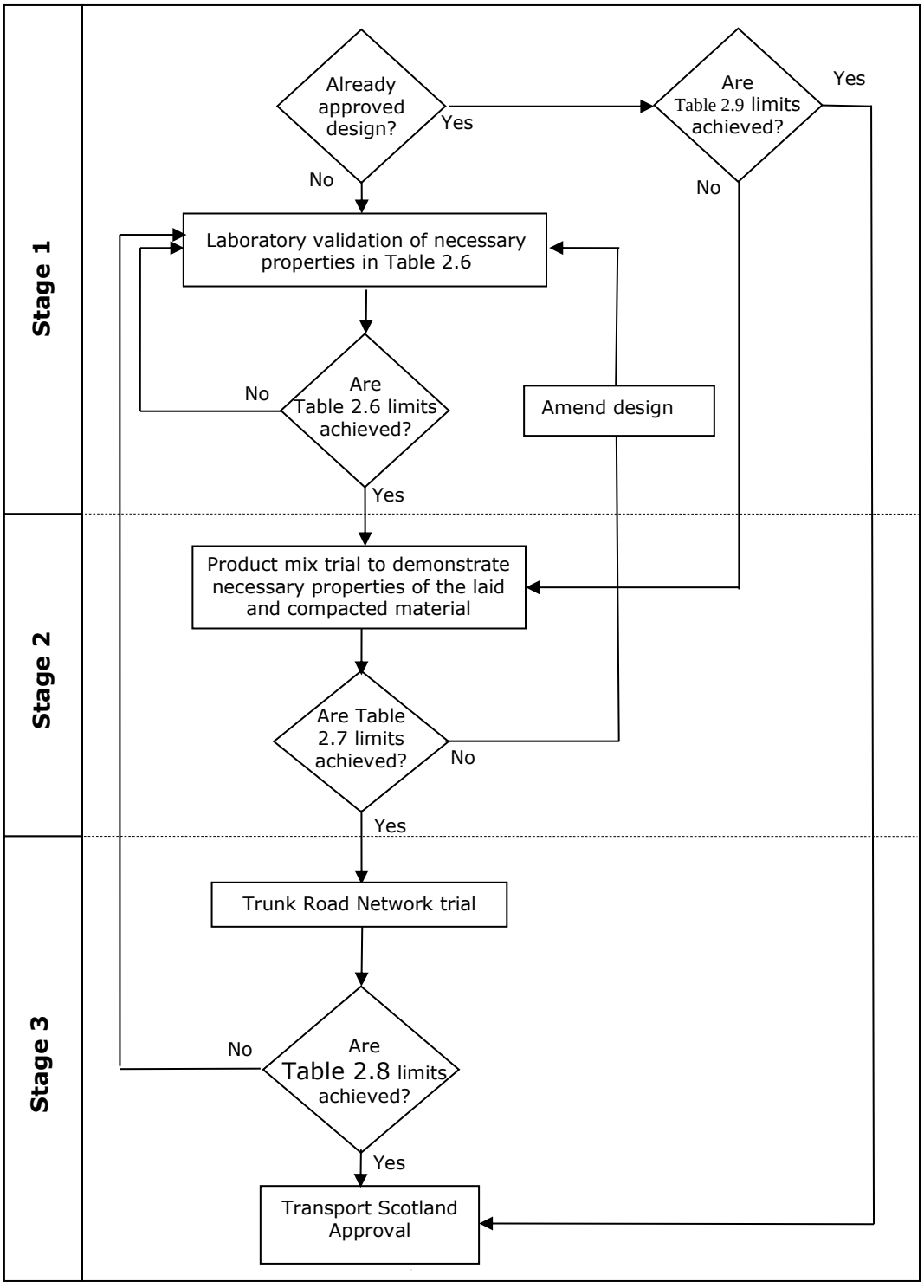


Figure 2.5: TAIT approval

2.12.4 Data recorded

An electronic report shall be submitted by the supplier with necessary information for each TAIT. This should include:

Information to be supplied for Stage 1 approval:

I. Summary of TAIT Stage 1 lab design results including:
   - Coarse aggregate source and geological rock type
   - Fine aggregate source and geological rock type
   - Filler source and supplier
   - Fibre type and supplier
   - Bitumen type and supplier
   - Expected manufacturing plant
   - Lab design properties against TS2010 requirements

II. Supporting test certificates or CE mark with the details of:
   - The coarse aggregate physicals
   - Aggregate grading and flakiness results – this may be on the CE certificate
   - Specified design property test certificates (binder drainage, wheel tracking, voids etc.)
   - Bitumen CE mark
   - Filler CE mark
   - Quality Assurance certificate for proposed production plant
   - Highways Sector Scheme 16 certification for proposed surfacing contractor

Information to be supplied for Stage 2 approval:

III. Summary sheet of TAIT Stage 2 test results including:
   - Summary of all bituminous analysis results

IV. Supporting test certificates including:
   - UKAS test certificate for texture depth of gritted and ungritted areas.
   - UKAS test certificate of void analysis from cores
   - Density Gauge results, correlation and measured voids

Information to be supplied for Stage 3 approval:

V. Summary sheet of TAIT Stage 3 test results including:
   - Summary of all bituminous analysis results

VI. Supporting test certificates including:
   - UKAS test certificates for texture depths of gritted areas
   - Test certificates of void analysis from density gauge
   - CSV files of 4 week and 6 month GripTester results

2.12.5 Information availability

The information from the TAIT shall be stored securely by the producer and a copy sent to Transport Scotland, Standards Branch, Buchanan House, 58 Port Dundas Road, Glasgow G4 OHF (email: TS2010TAIT@transport.gov.scot).

2.12.6 Approval Certificate

Following successful completion of TAIT Stage 3 procedures, Transport Scotland will issue an Approval Certificate indicating where the material can be used. This certificate will indicate the Site Class for which the material has achieved compliance, taking account of measured GripNumber and level of stress applied by traffic. An example form is shown in Annex A to this specification. This Approval shall be continually reviewed based on measured early-life GripNumbers from subsequent use of the material and informed by longer-term SCRIM performance. Approval Certificates will be updated based on the findings of such reviews.

Table 2.6: Set of tests for TAIT: Stage 1

Property	Test method/procedure	Limits
Coarse aggregate particle density	BS EN 1097-6	Results declared
Coarse aggregate resistance to polishing	BS EN 1097-8	Declared
Coarse aggregate resistance to abrasion	BS EN 1097-8, Annex A	AAV_{12}
Coarse aggregate resistance to fragmentation	BS EN 1097-2	LA_{30}
Coarse aggregate resistance to wear	BS EN 1097-1 Micro Deval method	$M_{DE\ declared}$
Flakiness	BS EN 933-3	FI_{20}
Air voids content*	BS EN 13108-20, Annex C	
SMA 6 (surf), SMA 8 (surf)		$V_{min3,5}$; V_{max4}
SMA 10 (surf), SMA 14 (surf)		V_{min3} ; $V_{max3,5}$
Binder content	BS EN 12697-1	Relevant column of Table 2.1A or Table 2.1B
Binder content for grit mixture	BS EN 12591	Relevant column of Table 2.3
Binder penetration	BS EN 1426	75 - 130
Binder softening point	BS EN 1427	≥75
Grading	BS EN 12697-2	Relevant column of Table 2.1A or Table 2.1B
Grading for grit mixture	BS EN 12697-2	Relevant column of Table 2.3
Binder drainage	BS EN 12697-18 Beaker method	$D_{0,3}$
Resistance to permanent deformation	BS EN 12697-22	WTS_{AIR1}

*See NG 2.4.1

Table 2.7: Set of tests for TAIT: Stage 2

Property	Test method/procedure	Limits
Air Voids in mat*	BS 594987, Annex G	
SMA 6 (surf), SMA 8 (surf)		V_{min2} ; $V_{max\ 6}$
SMA 10 (surf), SMA 14 (surf)		V_{min2} ; $V_{max\ 5}$
Binder content	BS EN 12697-1	Relevant column of Table 2.1A or Table 2.1B, to Clause 2.3.1 tolerance
Grading	BS EN 12697-2	The tolerance specified in BS EN 13108-21
Texture**	BS EN 13036-1	To be recorded

*See NG 2.4.2, **See NG 2.11

Table 2.8: Set of tests for TAIT: Stage 3

Property	Test method/procedure	Limits
Air voids in mat*	BS 594987, Annex I	
SMA 6 (surf), SMA 8 (surf)		V_{min2} ; $V_{max\ 6}$
SMA 10 (surf), SMA 14 (surf)		V_{min2} ; $V_{max\ 5}$
Binder content	BS EN 12697-1	Relevant column of Table 2.1A or Table 2.1B, to Clause 2.3.1 tolerance
Grading	BS EN 12697-2	The tolerance specified in BS EN 13108-21
Texture**	BS EN 13036-1	To be recorded
Mean GripNumber after 4 weeks and 6 months	BS 7941-2 TSIA 49	Mean GripNumber from relevant column of Table 2.5

*See NG 2.4.2, **See NG 2.11

Table 2.9: Test for alternative plant

Property	Test method/procedure	Limits
Binder content	BS EN 12697-1	Relevant column of Table 2.1A or Table 2.1B, to Clause 2.3.1 tolerance
Grading	BS EN 12697-2	The tolerance specified in BS EN 13108-21
Operating Compliance Level	BS EN 13108-21	Operating Compliance Level A or B

NG TS2010 Stone Mastic Asphalt Surface Course - Notes for Guidance

NG 2.1 General

The TS2010 specification is based on the common format and principles of BS EN 13108. This provides a way for a target mixture composition to be declared and demonstrate that certain defined properties have been achieved. However, it should be noted that, unlike BS EN 13108, the TS2010 specification is not restricted to requirements for the mixture produced at the plant, i.e. "in the back of the truck". For example, the specification includes requirements for air voids content of cores extracted from the laid and compacted mat (see 2.4.1). Requirements for applying grit to the surface course (see 2.9), and skid resistance (see 2.10) are also included.

In terms of Initial Type Testing and Factory Production Control, the procedures outlined in BS EN 13108-20 and BS EN 13108-21 are to be followed to demonstrate conformity with BS EN 13108.

Attention is drawn to the 900 Series of the *Specification for Highway Works* including Clause 903, *Placing and Compaction of Bituminous Mixtures*. Additional general guidance on the procedures for maximising the durability of asphalt pavements can also be found in Road Note 42 (Nicholls *et al*, 2008).

It should be noted that TS2010 has been developed primarily as a material intended to be machine-laid. It may not be suitable where circumstances require a high degree of hand-working, e.g. urban environment with a high density of road ironwork.

NG 2.2 Constituent Materials

NG 2.2.1 Binder

BS EN 14023 provides a framework of "classes" of polymer modified bitumen (PMB) with different properties. The selection of a class depends on the different characteristics that may be required, e.g. service temperature, cohesion, resistance to hardening and other properties. The choice of class will be strongly influenced by climatic and traffic conditions.

A PMB 75/130-75 has been specified for TS2010. This PMB has a penetration range of 75 to 130 (Class 7) and a minimum softening point of 75°C (Class 3). However, confirmation of all the properties listed in Table NG 2.1 will be required.

Table NG 2.1: Additional PMB information

Characteristic	Property	Test Method	Unit	Selected Class
Consistency at intermediate service temperature	Penetration at 25°C	BS EN 1426	0,1 mm	75-130 (Class 7)
Consistency at elevated service temperature	Softening point	BS EN 1427	°C	≥75 (Class 3)
Cohesion	Force ductility (50 mm/min traction)	BS EN 13589 BS EN 13703	J/cm^2	≥3 (Class 2)
Brittleness at low service temperature	Fraass breaking point	BS EN 12593	°C	≤ -20 (Class 9)
Strain recovery	Elastic recovery at 25°C	BS EN 13398	%	≥ 80 (Class 2)
Additional characteristics	Storage stability - Difference in softening point	BS EN 13399 BS EN 1427	°C	≤ 5 (Class 2)

It is recommended that the choice of PMB in accordance with BS EN 14023 is agreed between the bitumen supplier and asphalt manufacturer so that the characteristics required to meet the performance requirements of TS2010 are met.

In 2005, The German Asphalt Association recommended the use of PMB following problems with flushing, or loss of texture, under the action of heavy traffic. The predominant modification of bitumen used in Germany is by the addition of synthetic rubber, with their preference being for styrene-butadiene-styrene (SBS).

NG 2.2.2 Aggregates

NG 2.2.2.1.2 *Particle shape*

The coarse aggregate particle shape is important as it influences the arrangement and strength of the aggregate matrix and resultant surface texture. It is therefore important that the flakiness index is ≤ 20. A flakiness index of ≤15 is regarded as ideal.

NG 2.2.2.1.4 *Resistance to polishing*

The minimum PSVs to be applied to different categories of site and related to traffic flow are given in Tables 3.2a/3.2b of CD 236. However it has always been the case that other aggregates could be used where a satisfactory history of performance was available. With the introduction of the performance requirement for skid resistance within TS2010, and the adoption of a $PSV_{Declared}$ value in the contract, the opportunity to adopt and verify the satisfactory performance of aggregates with variant PSVs has been created. Accordingly values of PSV are required to be stated.

Sustainability objectives

With the safety-related aspects of choosing lower PSV surfacing aggregates satisfactorily addressed (by measuring their performance on the road), there is an enhanced opportunity for the wider use of durable local aggregates for surfacing roadstone on the Trunk Road Network. There has long been a strong economic case for using locally-won resources for surfacing, as opposed to importing high PSV material over long distances from England and Wales, but this has almost invariably hit obstacles due to the prescriptive nature of the default PSV requirements in the DMRB.

NG 2.2.4 Recycled materials

NG 2.2.4.2 Reclaimed asphalt

The use of an all-in graded reclaimed asphalt is not permitted owing to the requirements for consistent control of both binder content and grading requirements.

NG 2.2.5 Additives

In order to achieve the desired high binder content that creates a thick binder film in the TS2010 mixtures, a stabilizing additive is required. Currently it is possible to produce surfacing without the need for a stabilizing additive, i.e. with lower binder contents and the appropriate PMB. However, in addition to a PMB, the TS2010 specification requires an additive to act as a binder carrier to ensure the binder does not drain off the aggregate during production, storage and transportation.

As part of the TAIT process, the producer should provide evidence that technical studies have been undertaken to demonstrate that:

- Fibres are not pulverised or destroyed during dry mixing.
- Fibres do not clump together.
- Good fibre distribution can be achieved with different types of mixing plant.
- After 1 hour at the maximum expected mixing temperature at the mixing plant, binder lost by drainage is limited (see Beaker method, NG 2.5).

Although to a degree subjective, an assessment of the proportion of fibres recovered following binder extraction by sieving and weighing can be made. Around two thirds of the fibres should be retained on the various sieve sizes. If only one third or less can be detected then there could be a problem with fibre distribution. Experience has shown that if recovered fibres are dark brown and the *ring and ball* results are high, then the plant mixing temperature is likely to have been too high.

NG 2.3 Composition

Categorising the binder content in BS EN 13108-5 involves a correction for the density of the aggregate in the mixture. The principle is that the binder content category in the standard is based on an aggregate density in the mixture of 2,650 Mg/m³. If the aggregate is denser than 2,650 Mg/m³, the actual binder content in the true mixture is reduced proportionally, or if the aggregate is less dense, it is increased. This adjustment has the intention of giving the same binder volume in mixtures regardless of aggregate density.

A consideration of UK mixtures and aggregates indicated that this approach might have been detrimental to performance because, in practice, some of the denser aggregates need higher binder contents for durability. For this reason, the binder contents set out in Table 2.1A and Table 2.1B are those which are required as actual binder contents on analysis of the finished mixture with no density correction. These binder contents are referenced as B_{act}.

B_{act} will need to be corrected back to determine the B_{min} defined in BS EN 13108-5 using the following formula:

$$B_{\min} = \frac{\rho_b}{2.650} \times B_{act}$$

where ρ_b is the mean particle density of the aggregate mixture, in megagrams per cubic metre (Mg/m³), determined in accordance with BS EN 1097-6.

NG 2.3.1 Grading and binder content

The distribution of coarse aggregate greater than 2 mm for German SMA (0/11) is typically in the ratio of 4:2:1 for aggregate fractions 8/11:5/8:2/5. The high content of the coarsest aggregate is required to form a mixture that is gap-graded. Such grading is essential to create the desired coarse aggregate skeleton that will accommodate the mastic: i.e. binder, fine aggregate and filler. For illustration purposes, the distribution of mixture constituents for different types of asphalt is shown in Figure NG 2.1.

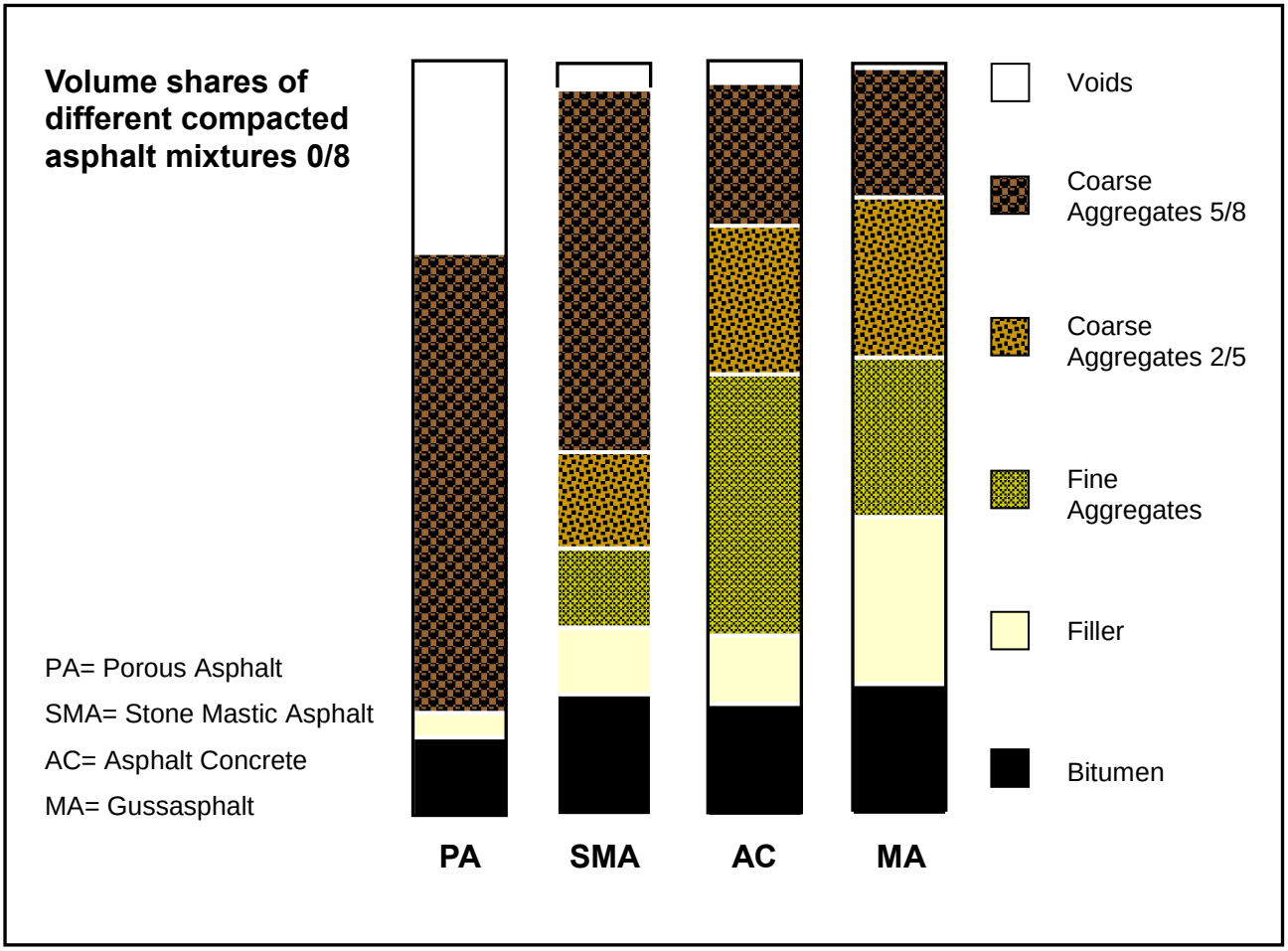


Figure NG 2.1: Composition of asphalt mixtures

SMA 8 (surf)

The introduction of SMA 8 will be a controlled one owing to a lack of industry experience in producing mixtures to such a grading. In particular, attention must be drawn to the use of a 5,6 mm sieve to control the grading of the SMA 8 (surf). This requirement is necessary to ensure that the mixture contains sufficient coarse aggregate in the 5,6 and 8 mm aggregate range.

Binder content tolerance

The use of a tight tolerance ±0,2% (by mass) on the binder content emphasises the importance of closely controlling the amount of binder in the mix. In addition, the target values given are higher than those used in current UK mixtures. Empirical evidence from Germany highlights that high binder contents, with a close degree of control, are a fundamental requirement in ensuring the durability of an SMA mixture. However, it should be noted that, because certain mix designs may be sensitive to binder content above a certain level, the supplier is recommended to use the lower limit of the tolerance as the start point for design purposes.

NG 2.4 Air Voids Content

NG 2.4.1 Laboratory prepared

The limits on the laboratory-prepared specimens are set at a tolerance such that the limits on the laid and compacted mat should subsequently be more readily achievable.

NG 2.4.2 Laid and compacted mat

The protocol described in BS 594987, Annex G relates to determining void content and resistance to permanent deformation of SMA binder course and regulating courses. As part of the Stage 2 TAIT, this protocol shall be used to determine the in situ void content of the SMA surface course only. The trial strip shall be as per Annex G but with a nominal thickness of not less than 40mm.

The average in-situ air voids content of the laid and compacted material undertaken as part of the Stage 3 TAIT Trunk Road Network Trial and subsequent laying operations shall be assessed using an indirect density gauge in accordance with BS 594987, Annex I, with readings taken at 20 m intervals in alternate wheel-tracks. Each gauge shall be individually calibrated for each mixture to be used. The calibrations shall be continually checked and updated based on correlations between gauge readings and core densities determined from the Stage 2 TAIT product mix trial. The compliance criteria (BS 594987 Annex I) shall be applied to a rolling mean of the values from three consecutive locations.

General

Correct compaction of the TS2010 SMA mixtures is important to ensure that a stable and durable pavement layer is constructed. Too low air voids content (<2%) can result in deformation under heavy traffic, while high air voids content (> 6%) can allow water and air to penetrate into the layer. This can lead to an increased potential for water damage, oxidation and subsequent aggregate loss or fretting under trafficking. Permeability can be a concern in SMA mixes as they utilize a gap-grade coarse gradation. For SMA 6 & 8 (surf) the range of 2 to 6% air voids content is considered to be acceptable, but for SMA 10 & 14 (surf) the range of 2 to 5% is deemed to be more appropriate, as these mixtures tend to become permeable when air voids content is above 6%.

NG 2.4.2.1 Surface course thickness

The values in Table 2.2 are taken from BS 594987 (Table 1C) with the exception that the maximum laid thickness for SMA 14 has been increased. The values for SMA 8 are the same as those for SMA 10 but with a decreased maximum thickness. The optimum thickness will be influenced by factors such as seasonal/climatic conditions and the nature of the works, in order to balance cost, durability and sustainability to provide best value.

NG 2.5 Binder Drainage

The Beaker method (BS EN 12697-18) describes a procedure for determining the binder drainage of asphalt mixtures incorporating fibres and enables the effects of any anti-draining additive to be quantified. The TS2010 specification requires that the difference between the mixture mass before and after heating is less than 0,3%. With percentages based on experience of using the test in Germany, Table NG 2.2 provides additional guidance on assessing the performance of the additive.

Table NG 2.2: Guidance on binder drainage results

Average binder drainage D (%) (as per BS EN 12697-18)		
<0,2	**0,2 – 0,3**	**>0,3**
Good	Acceptable	poor

Where mixing plants are situated long distances from the laying site, or where long truck waiting times are taking place, it is recommended that the material at the point of delivery to the paver should be checked to ensure that no significant binder drainage has taken place.

In many countries around the world, shuttle buggies (Figure NG 2.2) are used successfully to remix the hot asphalt just before it is placed. This reduces the incidence of material segregation and temperature variations caused by subjecting the material to long haul distances or waiting times.

Figure NG 2.2: Example of shuttle buggy in operation

NG 2.6 Water Sensitivity

The test method as specified in BS EN 12697-12 should be used in preference to other methods if water sensitivity is considered to be an issue with the aggregate to be used.

NG 2.9 Grit for the Application to Surface Course

The TS2010 SMA mixtures, when new, will have a thicker binder film than most conventional asphalts. In the surfacing's early life the binder film can prevent the microtexture on the aggregate particles making contact with a tyre, resulting in potentially lower wet friction than might normally be expected. It has therefore been decided that crushed grit shall be applied to the surface at the point of laying to increase the early-life skid resistance. The application of grit also assists in accelerating the removal of thick binder films from the aggregate at the top of the surface course.

NG 2.9.2 Material

NG 2.9.2.2 Grading

The portion of aggregate allowed to pass the 2 mm and 1 mm sieves for 2/4 mm grit and 1/2,8 mm grit, respectively, has been set at a maximum of 25% by mass. In Germany, the maximum is set at 15%. This latter limit if achievable is the more desirable as it minimises the amount of fine aggregate or dust present in the grit used.

NG 2.9.2.3 Binder content

A target binder content range is given in the specification. It is important that the binder is applied in small amounts and this will be governed by the type of plant available. The overall aim is to ensure that the grit is free flowing and is not prone to clumping.

NG 2.9.3 Application

It is important that the grit is applied promptly and properly rolled to maximise the adhesion of the grit to the surface of the newly-laid mat.

NG 2.10 Skid Resistance

A performance requirement has been introduced into this specification for the skid resistance testing of TS2010 material in the newly-laid and early-life condition. This has created an opportunity to adopt a more flexible approach than customary to the specification of PSV and the techniques used for the measurement of skid resistance.

TS2010 is not necessarily seen as a replacement for High Friction Surfacing (HFS) and where elevated levels of skid resistance are deemed necessary HFS should still be considered.

NG 2.11 Texture

The surface course shall exhibit a uniform macrotexture. Texture measurements are to be taken and recorded for monitoring purposes but no specification requirements for texture depth will apply. Measurements are required to be taken as part of the product mix trial (Stage 2). Areas both with and without grit shall be tested and reported as part of Stage 2 of the TAIT. Following site laying on the Trunk Road Network (Stage 3) and subsequent to mixture approval, measurements should be taken in the gritted condition where possible and reported.

NG 2.12 TAIT

NG 2.12.2 General requirements

The TAIT comprises a three stage process: laboratory study, product mix trial and Trunk Road Network trial. The laboratory study (Stage 1) relates to designing a mixture that meets the specification. The product mix trial (Stage 2) provides the opportunity to assess the behaviour of the mix under compaction and enables the collection of information that provides the necessary properties of the laid and compacted material. The product mix trial is not permitted to form part of any permanent Trunk Road works pavement, and should comprise at least one 20 tonne batch of the design mixture proposed. The compacted material in this trial should be gritted in accordance with the specification. It should be emphasised that the product mix trial is not a trial on the network and is intended to allow the supplier to become familiar with the process of

manufacturing and laying the material. Transport Scotland must be given sufficient opportunity to witness the Stage 2 product mix trial.

Following the completion of a satisfactory product mix trial, a Trunk Road Network trial (Stage 3) can then be undertaken. The site of the stage 3 trial must be approved by Transport Scotland and Transport Scotland must be given the opportunity to witness the trial. Following satisfactory completion of this, confirmation of formal approval to use the product will be given in the form of an Approval Certificate.

NG 2.13 Paving and Compaction

NG 2.13.1 Joints

The durability of the surface course, and underlying pavement, can be extended by limiting the number of longitudinal and transverse joints. Careful planning of the paving works should always be undertaken in order to limit the number of joints. Echelon paving should be adopted whenever feasible.

NG 2.13.1.1 Location

Longitudinal joints shall not be located within wheel track zones. These areas are typically located in zones between 0.5m and 1.1m from lane markings. All joints must be laterally offset from parallel joints in the layer below by at least 300mm.

Transverse joints are always made as a consequence of any interruption to the paving works. Such joints create a local weakness in the pavement, resulting in a shorter service life. Careful planning can reduce the number of stoppages. Transverse joints often also disrupt the smoothness of the longitudinal profile and hence ride quality of the pavement surface. In some instances the poor longitudinal profile created in the area of transverse joints can result in additional dynamic loading that is damaging to the pavement.

NG 2.13.1.2 Construction

The first lane paved is often referred to as the *cold lane* because the hot asphalt cools off by the time the second lane, or *hot lane* is being paved. In addition to the fact it will remain cold when the hot lane is laid, the unconfined edge of the cold lane tends to have a lower density than at the centre of the lane. Maintaining consistent density across this joint is key to the construction of a durable longitudinal joint. The techniques described below have been used to improve the construction of an unconfined edge of which the side compaction wheel is preferred.

NG 2.13.1.3 Side compaction wheel

The use of an edge compaction technique to construct a longitudinal joint is popular in Germany. It consists of a hydraulically-powered wheel, which rolls alongside the compactors drum. The wheel pinches the unconfined edge of the first lane towards the drum. The method is believed to increase the density of the unconfined edge and improve the overall density at the joint. The edge-restraining wheel is bevelled up toward the roller at a range of angles dependent on the thickness and type of material. The bevelled edge produced by the technique provides a longer jointing surface which is thought to improve the adhesion and quality of the joint between lanes.

It should be noted that the technique described above produces a slightly raised profile which can be removed by using the tandem roller in crab-steer mode, i.e. with the rear drum offset by approximately 100mm.

NG 2.13.1.4 Cutting back

The conventional way of treating material at the edge of the surface course cold lane is to carefully cut it back to its full depth. This removes material that is not sufficiently compacted and ensures that the hot lane is laid and compacted against a firm and uniform material. The quality of the joint is dependent upon the skill of the cutting wheel operator. After cutting back the exposed vertical edge must be thoroughly cleaned of all loose material and be sealed with an approved bituminous joint seal in accordance with BS 594987.

The painting of joints is intended to aid adhesion and minimise the ingress of water at the joint. It is therefore vitally important that the vertical face of the cut and cleaned joint is completely coated with the chosen sealant.

NG 2.13.1.5 Joint re-heating

The quality of longitudinal joints may be aided by heating the joint with an approved joint heater. The concept is to re-heat the edge of the cold lane and bring it up to a plastic state prior to the new, adjacent hot mat being laid. The heater must raise the temperature of the full depth of the surface course to within the specified range of minimum and maximum rolling temperatures for a width of not less than 75 mm. It should be noted that if the process is not carried out in a controlled manner there is a danger that heated asphalt may be damaged which can result in premature ageing of the material.

NG 2.14.2 Bond coats

Requirements for bond coats are covered in Clause 920 of the SHW (MCHW 1). Such bond coats are used to promote adhesion and provide some waterproofing capability. Approval to use non-BBA bond coats must be sought from Transport Scotland and details shall include properties and spread rate. The pavement surface receiving the bond coat should be as clean and dry as possible. Existing pavements can be dirty and dusty, and there is a possibility that the bond coat may merely adhere to the dirt and dust rather than the pavement layer to be surfaced.

There can be a problem with the bond coat adhering to asphalt delivery vehicle tyres during hot weather or where haulage has been over a considerable distance, i.e. the vehicle tyres become very hot. In Germany water is often used to cool down vehicle tyres before they traverse surfaces that have been treated with a bond coat (Figure NG 2.3). Water is often applied on the approach to the site and is seen to reduce the amount of bond coat pick-up on vehicle tyres.

Figure NG 2.3: Watering of surface to avoid sticking of bond coat to tyres

NG 2.14.3 Compaction

The TS2010 SMA could possess all the desirable design mixture properties but still perform poorly under traffic if it has not been compacted correctly. As a result of the compaction process, the binder coated aggregates are forced closer together increasing aggregate interlock and inter-particle friction. Proper compaction of the asphalt increases resistance to rutting, cracking, ageing, moisture damage and stability of the mixture.

Experience with laying SMA in Germany is that the temperature of the material in the paver hopper should be evenly distributed and not be at less than 150°C. Compaction of the mat should commence as soon as possible. All rollers should be smooth steel-wheeled. Rollers should operate as close as possible to the paver. It is considered best practice to have at least two rollers for each lane that is paved. Pneumatic-tyre rollers are not suitable as binder-rich material adheres to them. The use of the vibration function on rollers should be avoided as there is a risk that excessive vibration on cooled material will fracture and damage the surface aggregates.

It is recognised that where small quantities of material are being used, e.g. small areas and patching work, a tandem roller may be sufficient.

All compaction equipment used shall be operated by skilled and experienced operators. Skilled equipment drivers are required to observe and react to any detrimental movement of the asphalt. Due to the number of variables involved, such as environmental conditions and mix properties, it is impossible to generalise about the best combination of rolling and roller pattern to use in all cases. However, a 'slow and steady' approach is regarded as desirable to increase both the quality and long-term durability of the rolled pavement. The following should be noted:

- Stoppages in rolling can lead to variations in layer density.
- Too high a rolling speed may result in insufficient compactive effort being applied.
- Large variations in roller speed along the length or across the width of the mat is likely to cause variations in the density achieved.
- Rollers should be turned slightly to the side when reversing direction or stopping (Figure NG 2.4). It is difficult to flatten out marks or indentations if they are perpendicular to the direction of roller travel. It is easier to flatten or remove marks with subsequent passes if they are diagonal to the direction of rolling.

Figure NG 2.4: Roller compaction behind paver

NG 2.15 Surfacing Selection

The TS2010 specification comprises a range of four SMA mixtures. Guidance on what mixture should be specified (represented by the greyed-out areas) is provided in Table NG 2.3. However, it should be noted that experience in using the TS2010 specification is at an early stage and the decision as to which mixture is selected should always be made on a site-specific basis.

Table NG 2.3: Guidance on the selection of TS2010 SMA mixtures

Mixture description	Site category/description					
	Non-event	Medium risk of Skidding	High risk of Skidding	Noise sensitive area		High stress
	e.g. Site Class 1[a]	e.g. Site Class 2[b]	e.g. Site Class 3[c]	High speed	Low speed	e.g. roundabouts & junctions
SMA 14						
SMA 10						
SMA 8 (Developmental)						
SMA 6						

a) Site Class 1 comprises site categories A, B & C given in Table 4.1 of HD28 (DMRB 7.3.1)
b) Site Class 2 comprises site categories R, G1 & S1 given in Table 4.1 of HD28 (DMRB 7.3.1)
c) Site Class 3 comprises site categories Q, K, G2 & S2 given in Table 4.1 of HD28 (DMRB 7.3.1)

3 References

Nicholls, C, M J McHale and R D Griffiths (2008). *Best practice guide for the durability of asphalt pavements.* TRL Road Note, RN42. Wokingham: TRL Ltd.

Annex A Example of Approval Certificate

Asset Management Branch
Trunk Road and Bus Operations
Buchanan House
58 Port Dundas Road
Glasgow G4 0HF

Transport Scotland TS2010 Surface Course

Approval Certificate

Scotia Aggregates Ltd.

Ref N^{0}: Sc 01

Details of material:

Coarse Aggregate:	Blackrock Quarry
Fine Aggregate:	Whiterock Quarry
Filler Aggregate:	Powders Hill
Mixing Plant:	Southbank
Aggregate size:	10mm
Bitumen:	Eurobinders SBS Polymer modified
Fibres:	Celluproducts C1 pellets

This material is approved for use on **Class 1** sites based on the results contained within TAIT report Sc 01 (xx/xx/xxxx)

The above material is approved to be produced at the following plants, in code order:

Sc 01	Southbank (original plant)
Sc 01a	Westbank
Sc 01b	Eastbank

Signed: ..... xxxxx ..... For Transport Scotland
[*Print Name*]
[*Title*]

Latest Revision Date: xx/xx/xxxx
Original Approval Date: xx/xx/xxxx