ROADS AND MARITIME SERVICES (RMS)

QA SPECIFICATION R121

STONE MASTIC ASPHALT

REVISION REGISTER

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Ed 2/Rev 1	2.1.3 Annex M	Reference to spec RTA 3054 changed to RTA 3211. Reference to spec RTA 3054 deleted.	GM, IC	02.11.10

GUIDE NOTES

(Not Part of Contract Document)

USING SPECIFICATION R121

Specification RMS R121 is a QA specification and the use of QA specifications requires the implementation of a quality management system by the Contractor that meets the quality management system requirements specified in Specification RMS Q. To comply with the intention of government policy as well as RMS R121, Stone Mastic Asphalt works constructed using RMS R121 require adequate surveillance and audit by the Principal.

RMS R121 requires the RMS Project Manager to select appropriate parameters identified in RMS R121 and nominate them in Annexure R121/A. The Project Manager is also required to select an appropriate version of RMS Q commensurate with the size of the project and the risk to the Principal.

Introduction

Stone Mastic Asphalt may be referred to by the acronym SMA. It is promoted primarily for use as a surfacing course with relatively high surface texture, low permeability and a high resistance to rutting. The coarse texture tends to reduce the generation of spray during rain periods.

In practice, there is a chance that SMA supplied under this first edition of the specification may be more permeable than expected and pavement designers will need to take this into account. In some cases, the application of a sprayed seal will be warranted prior to placing SMA. Development and/or evolution of the product is expected to continue with a view to minimising permeability and this should eventually lead to the specification of lower air voids limits without unacceptable risk of flushing.

SMA is generally not used lower in the pavement as structural asphalt because of its relatively high cost and lower design stiffness both of which tend to result from a relatively high binder content. Pavement designers are advised to check with RMS Pavement Projects Branch in respect of design stiffness for SMA.

SMA is designed with a high proportion of coarse aggregate to generate stone on stone contact between the coarse aggregate particles within the mix with the resulting skeletal voids being partially filled by the mixture of binder and fines (mastic). Thus the inter-particle friction of the coarse aggregate is a significant consideration and care must be taken in the selection of source in terms of shape, fractured faces and particle microtexture.

The mix design and the subsequent production process must ensure that the voids in the coarse aggregate skeleton are sufficient to contain the mastic and the appropriate air voids if performance is to be realised. To achieve this, the aggregate will have good shape and the grading will generally be coarse and gapped in the vicinity of the 2.36 mm and 4.75 mm AS sieves. The quality of aggregate supply must be consistent for the duration of the work and to this end, the use of museum samples (glass containers of the constituents used for mix design purposes) as a surveillance tool is strongly recommended.

The relatively high proportion of binder/mastic requires special attention to be paid to aspects of process if a homogeneous product is to be achieved. These include the possibility of segregation due to insufficient mixing time, binder drainage during haulage, binder segregation during paving/rolling and flushing on opening to traffic.

SMA supplied under this specification is intended to be used as a relatively thin wearing surface and has a service life of approximately 10 years.

The quality and surface condition of the existing pavement impacts on the suitability and performance of SMA. Existing pavements with low deflection/curvature, good shape and free of cracking offer the best chance of success.

RMS Project Managers may obtain a general guide and past performance information from RMS Pavement Projects Branch. An AAPA Guide to SMA is currently being prepared.

Edition 1

Edition 1 was the initial issue version of the specification and was expected to require upgrading on the basis of field experience. Comments and suggestions should be forwarded to the Manager, Contracts Quality, Infrastructure Contracts Branch.

TECHNICAL REFERENCE NOTES

Clause 1.2.4 References

In response to Industry requests, RMS test methods have been largely substituted by Australian Standards. In most instances, the Australian Standards are the same or very similar to the RMS Test Methods but Contract Managers are advised to make themselves aware of the content of these newly specified Standards

Clause 2.1.1(a) & Clause 2.1.2(a) Grading Requirements

Aggregate cleanliness has a significant influence on the effectiveness of binder coating. The additional requirement to determine the proportion of 75 micron material by washing gives an indication of the cleanliness of the aggregate. A comparison between the proportion of 75 micron determined by wet and dry sieving respectively gives an indication of adhering dust.

Under generally accepted industry standards, aggregates of 10mm nominal size and greater are normally considered clean if the proportion less than 75 micron is less than 1% (for a 5 mm aggregate the proportion should be less than 2%). These measures do not directly address adhering dust.

In cases where production techniques, dust suppression procedures, weather and weathering cause these general limits to be exceeded, the matter should be dealt with as a condition adverse to quality requiring corrective action.

Clause 2.1.1(b) & Clause 2.1.1(c) Shape and Crushed Particles

These parameters are very important to the performance of SMA and it is desirable that selected aggregate sources demonstrate test results well within the specified limits. Aggregates derived from river gravels are not a preferred SMA constituent but if used, must be crushed from quite large spalls in order to effectively eliminate rounded surfaces.

Whilst not currently done in Australia, it is not uncommon in some other countries to double crush aggregates for use in SMA. The more cubical the aggregate shape, the better the surface texture and performance of the SMA.

Clause 2.1.1(e) Resistance to Stripping

It would be desirable that the Plate Stripping Test AS 1141.50 (RMS T230) be conducted using the binder which has been specified for the works. However, pending the outcome of a proposed review of test, resistance to stripping of the coarse aggregate may be assessed using C170 binder conforming to AS 2008 in lieu of the binder specified for the works. Adequate adhesion between the binder and aggregate in an asphalt is considered to be a high priority issue.

As a matter of perspective, the Plate Stripping Test is a relative measure of relative binder adhesion to aggregate. Moisture sensitivity is a broader consideration and depends, for example, on other issues such as cleanliness of aggregates and effective coating of aggregate with binder. Longer mixing times are generally required for effective mixing of SMA particularly when constituents include polymer modified or multigrade binders and hydrated lime.

Clause 2.1.1(f) Frictional Characteristics

Except in the case of pavements with high skidding risk, the specified limit for minimum PAFV would generally not exceed 48 and would never be less than 44.

For pavements with high skidding risk, special aggregates with PAFV up to approximately 60 are available for use in asphalt but these often present other challenges in respect of asphalt mix design.

It should be noted that there are other factors as well as PAFV which may influence the skid friction characteristics of a pavement surface. RMS Project Managers are advised to consult the Vicroads/RMS 'Guide to the Measurement and Interpretation of Skid Resistance using SCRIM'.

Clause 2.1.1(g) & Clause 2.1.2(c) Water Absorption

The limits specified for water absorption have been set to facilitate the use of steel furnace slag aggregate. Desirable limits on conventional aggregates would be at least 1% lower.

Clause 2.1.2(b) Angularity

A requirement on angularity has been introduced because the specification allows up to 50% of fine aggregates which may be other than crushed rock. [Refer Clause 2.2.1 (a)]

For the purpose of this requirement it is expected that, the Contractor will verify conformity of a laboratory blend of fine aggregates prepared in accordance with the mix design proportions. Determination of angularity of individual constituents would serve only to gain an appreciation of or rank those constituents.

An acceptable alternative to the specified AASHTO test method is ASTM C1252 Method 'A'.

Refer also to Guide Notes on Clause 2.2.1.

Clause 2.1.2(e) & Clause 2.1.3(c) Methylene Blue Value

Methylene Blue Value (MBV) in excess of 10 is an indicator of risk of moisture sensitivity due to the presence of reactive clays and/or other deleterious matter. If this occurs, the matter should be raised with the Contractor as a possible condition adverse to quality.

As with other asphalt design parameters, there may be opportunity to engineer the SMA product to offset the risk and the Contractor should be given an opportunity to reconsider the adequacy of the design.

The symptoms of moisture damage may include rutting, ravelling, potholing and cracking.

Clause 2.1.3 Added Fillers

Filler may be naturally occurring within the process (eg rock dust in the aggregate feed) or it may be separately imported from an external source and "added" to the process.

The rock flour referred to in Clause 2.1.3 (c) is an added filler and does not include the rock dust normally occurring in the aggregate feed which is separately addressed under aggregate requirements.

Clause 2.1.4 & Annexure R121/A Binder Selection

The guide notes attached to RMS binder specifications make recommendation on suitable selection of binder for a variety of applications. In the case of SMA, RMS Project Managers are advised to consider the binder recommendations relating to rutting resistance.

In most instances, it is expected that the specified binder will be either polymer modified or multigrade.

Clause 2.1.5 Additives

Whilst it is recognised that development work is being under taken with a view to substituting or eliminating fibre additive, it has been found that control of binder draindown may be only one of the benefits of fibre additive in achieving good overall performance of SMA. Consequently, this specification currently requires the inclusion of fibre additive in SMA.

One of the more commonly used fibre additives in Australia has been an imported cellulose fibre with a typical specification as follows:

Apparent density	25 - 35 grams per litre
Maximum fibre length	5.00 mm
Average fibre length	1.10 mm
Average fibre thickness	0.045 mm

Other forms of cellulose fibre (and indeed other types of fibres such as rock fibre) are available and may be used but there has been limited experience with them in Australia. The different nature of the various fibres means that they may not be substituted 1 for 1 by mass in an asphalt design.

A typical binder drainage test is the Schellenberg Test which basically involves heating of an SMA sample in a beaker and determining the mass of binder paste retained in the beaker when the SMA sampled is removed. The Industry accepted limit under the Schellenberg Test tends to be maximum 0.3% of total mass of SMA sample retained in the beaker.

Clauses 2.1.6 & Annexure R121/A Bitumen Emulsion Tackcoat

The normal requirement of a bitumen emulsion tackcoat material is the same as for dense graded asphalt. However, in applications where delamination is considered to be a significant risk (eg thin layers or marginal quality existing pavement and/or drainage), interlayer adhesion may be improved by specifying the use of polymer modified bitumen emulsion.

RMS Project Managers should bear in mind that special arrangements in terms of logistics may be necessary to source and use modified tackcoats and the benefit/cost should be considered.

Clause 2.2.1 Proportions of Constituents

The proportion of the fine aggregate derived from crushed hard rock quarry material (ie fully crushed particles) affects the deformation resistance of SMA. Whilst the specification limit is 50% minimum, it may be necessary for the Contractor to increase this proportion to as high as 100% to achieve acceptable deformation resistance in some circumstances. In cases where the Contractor is using 100% crushed fine aggregate, the Contractor may propose and implement, subject to the approval of the Principal, a disposition which includes non-conformity to the requirement of Clause 2.1.2 (b) - Angularity.

The specified proportion of hydrated lime is considered to be the minimum requirement for added filler for the average circumstances. For high performance applications, mix designers may include

higher proportions of added filler(s) to generate higher dry compacted voids (DCV) or substitute for more natural material in the filler fraction. It should be noted that high DCV fillers generally require the incorporation of a higher proportion of binder than would other added fillers if the crack resistance of an asphalt is not to be compromised.

The specified binder content range is applicable to commonly used natural sources of asphalt aggregates and sands. If the contractor proposes to use constituents of substantially different density (for example, steel furnace slag), then the contractor may propose and use, subject to the Principals agreement, a non-conforming binder content provided that the Contractor demonstrates volumetric proportions within the proposed SMA which are consistent with the intent of the specification.

Clause 2.2.2 Combined Particle Size Distribution (Grading)

This specification currently relies on the Contractor designing a grading which ensures suitable voids in the coarse aggregate and thus stone on stone contact of coarse aggregate particles with acceptable overall volumetrics.

To some extent, Contractors are able to verify the volumetric suitability of the grading by design procedures which involve iterations of incremental adjustment to fine aggregate content. There are a number of tests of this ilk. For example, Department of Main Roads, Queensland currently specifies a test for mix volume ratio for which is set a limit of 1.00. This test purports to compare the volume of voids in the coarse aggregate fraction to the volume of binder and fines available to fill those voids.

Notwithstanding the above, it should be noted that more reliable assessment of design may be made by laboratory performance testing.

It should also be noted that the nominated mix is required to comply with the limits specified in Table R121.2 but production tolerances are not required to fall within these limits which is a departure from some other RMS specifications. Whilst the current limits have been developed on the basis of a range of performing product, RMS general preference is for the SMA grading to tend to the coarser side of the envelope.

Clause 2.2.3 Voids in SMA

Performance of asphalt is dependent on mix volumetrics and RMS would be seeking consistency in the results reported for laboratory compacted air voids and VMA. Assessment of consistency is best done on the basis of rolling average and rolling range and close control is recommended for SMA.

At this point it is important to note that VMA is calculated as the sum of air voids and effective binder content. Thus, for given air voids, a reduction in VMA effectively means reduced binder film thickness and increased risk to asphalt durability in service.

The specified limits for laboratory compacted air voids are relatively wide because of anticipated variability in test results on production mix. Notwithstanding this, it is intended that the design should target 5% laboratory compacted air voids at 80 or 120 cycles (whichever is specified).

Voids in laboratory compacted SMA is assessed at levels of compaction which are intended to represent the predicted traffic loading in service. The RMS Project Manager is required to specify one of the following levels of compaction in Annexure R121/A:

Loading Category	Cycles of laboratory compaction	Field Application
Heavy	120 and 350	Approaches to intersections and/or junctions (minimum 50m length) and turning bays. Areas of speed restriction, curves and/or grades which would cause commercial vehicles to travel < 80 kph.
Normal	80 and 350	Commercial vehicles travelling > 80 kph in applications not covered by option 1. Light traffic at other than approaches to intersections and/or junctions.

Clause 2.3.1(c) Validity of Test Certificates

The provision that all testing should have been completed within the past twelve months is intended to allow the contractor to submit a suitable nominated mix which may have been established for another contract. It is assumed that minimum frequency of testing of product and constituent will have been conducted as specified.

Proper and effective mix design and process control necessitates the use of current and compatible data. It is well recognised within the industry that constituent sources may be variable and it is always advisable to obtain and use up-to-date information throughout all phases of the contract.

Clause 2.4.1 Methods of Production

Not all existing plants/processes in NSW are currently considered to have the capability to reliably and consistently manufacture a quality SMA. Contractors are expected to make responsible decisions in this regard and for some, without making upgrades or alternative arrangements, the supply of SMA will not be an option.

RMS Project Managers are encouraged to discuss capability with local industry representatives before specifying SMA.

Clause 2.4.3 Storage and Handling of Binder and SMA

The storage of SMA in hot storage silos is to be avoided wherever possible and particularly in cases where long haul distances are involved. It must be recognised however that many manufacturing plants load out into trucks through hot storage silos and that these silos should be operated at least partly filled in order to minimise segregation.

Clause 2.4.4 Temperatures of Materials

The aggregate is generally the highest temperature component in the manufacturing process and the cellulose fibre is generally the most sensitive to heat damage. Thus, whilst high mix temperature may be desirable for laying and compaction purposes, there are practical limitations on SMA manufacturing temperatures which should generally not exceed 175°C for the mix and 190°C for the component aggregates.

Clause 2.6 Transport

Long haulage distances/times are not recommended because of the risk of binder segregation. This form of segregation is not always immediately evident as ‘free binder’ in the truck body but may become evident at a later stage as fatty spots in the SMA pavement. This form of segregation should not be confused with the occasional dislodgment of minor amounts of fines build up from corners or edges of the paver screed during placement operations.

In circumstances where long haul distances/times cannot be avoided, the use of SMA is not a recommended option.

Clause 3 Preparation of Pavement

The following items are not normally expected to be provided under this Clause 3,

- correction of surface defects' as detailed in Section 4.1 of AS 2734
- 'pretreatment' in the form of a sprayed seal as detailed in Section 4.2 of AS 2734.
- 'herbicide treatment' and 'treatment of existing oil contamination' as detailed in Section 4.3 of AS 2734
- 'raising of utility and manhole covers' as detailed in Section 4.4 of AS 2734.

However, all contamination introduced by the contractor, must be removed by the contractor irrespective of its nature.

Clause 4.5 of RMS R121 takes precedence over Section 4.5 of AS 2734.

Clause 4.1 General

Non-homogeneous material may be evidenced visually or by poor performance. Clause 4.10 tends to deal with the visual criteria whereas, by requiring 'sound' surface, it is the intention of Clause 4.1(a) to deal with the short term performance issues (such as localised ravelling) which may not have been readily apparent on initial surface inspection.

The operation of the self-propelled paving machine should be such to minimise the occurrence of cooled material in the paving process. Thus, every effort should be made to avoid stop/start work and other interruptions to the flow of material through the paving machine.

A useful aid in minimising temperature segregation in the field process is a suitable Materials Transfer Device (MTD).

Clause 4.2 Protection of Work

If the SMA is subjected to the action of motor vehicle tyres before having cooled sufficiently binder/mastic may be drawn to the surface causing flushing and loss of texture.

Rapid cooling of SMA by addition of water is not permissible whilst the binder/mastic is at relatively low viscosity because of the risk of moisture damage to the SMA.

Clauses 4.4 & Annexure R121/A Course Thickness

The specified course thickness of SMA should be within the ranges in the following Table

Nominal size of SMA	Allowable range for specified thickness
10 mm	≥ 25 mm to ≤ 35 mm
14 mm	> 35 mm to ≤ 50 mm

SMA is currently considered to be a wearing course and thus specified course thickness should tend to the lower end of the allowable range as far as existing pavement shape and expected compaction conditions will permit. In this respect, specified course thickness should take account of the need to achieve a dense homogeneous mat over high spots on existing pavements which have poor shape, expected air and pavement temperatures during placing and the type of binder specified.

Other things being equal, thinner layers of a given SMA will tend to be more rut resistant than thicker layers. Thinner layers will also tend to be less workable and more stable under compaction rollers.

Attention is drawn to the guide notes on Clause 5.1(a). If the likely consequence of paving a single course over a poor shape pavement is to have significant areas of SMA at a depth exceeding 4 times the nominal mix size, then consideration should be given to the inclusion of a corrective course in the pavement design.

Clause 4.5 Temperature and weather conditions

SMA may need to be placed at night, particularly in city locations, and the minimum specified pavement temperature of 25°C for various wind velocity conditions may at times be difficult to achieve. In such circumstances, the Contractor may propose and implement, subject to the Principal's approval, a lower limit not less than 15°C provided that the Contractor's proposal includes details of necessary changes to rolling equipment, rolling techniques and in-process monitoring to deal with reduced time available due to rapid cooling of the SMA.

Notwithstanding the above, the lower limit of 10°C referred to in Clause 4.5(a) should be upheld.

Clause 4.6 SMA temperature for laying

The minimum temperature which placement and initial compaction of SMA must achieve is 110°C which may vary slightly depending on binder type.

Whilst the temperature regime is not dis-similar to other hot mixed asphalts, the particular difficulties sometimes associated with successfully compacting SMA (also referred to in other sections of these notes) tend to make laying temperature a more important consideration.

There are practical limitations on the use of conventional compaction equipment if segregation of binder/mastic is to be avoided and, because SMA is usually paved in thin layers and will generally incorporate polymer modified binder, the rate of temperature loss in the mat is relatively high.

Thus manufacturing, transport and laying temperatures must be as high as practical without causing damage to the fibre additive or creating binder drainage. As a general rule, SMA will need to be placed and subject to initial compaction at a temperature of at least 140°C. Experience has shown that target laying temperatures would generally need to be at least 160°C depending on binder type.

Clause 4.8 Compaction

Recent laboratory studies have established the high dependence of rut resistance on compaction and this in turn highlights the need for good field compaction practices to ensure that the mix performs satisfactorily. The coarse aggregate content of the mix means that it tends to achieve stone on stone contact fairly quickly and so effective compaction rather than excessive compaction is the key to success.

The specification limits for characteristic values of insitu air voids are relatively wide because of anticipated variability in test results. With a design air voids target of 5%, the contractor must target not more than 6.5% mean insitu air voids in order to achieve at least 98% relative compaction. This is a vital consideration in minimising post construction compaction which, if it occurs, may be expected to contribute to closing up of the mix and possible poor performance of the SMA.

Inappropriate compaction techniques may draw binder to the surface of an SMA causing flushing of the surface and loss of texture. Binder segregation of this nature can be caused by the vibrations of steel rollers and the action of rubber tyred rollers. Rubber tyred rollers are generally not recommended for use on SMA but, if necessary, may be used for final rolling at relatively low temperatures.

Compaction must commence immediately after the mat is placed and must be completed quickly and effectively without generating segregation of binder/mastic or poor riding quality. To this end, it may be noted that the use of large heavy steel rollers (10 to 15t) increases coverage per roller pass and compactive effort without the need for vibration.

Final rolling should immediately follow initial rolling and be completed before the SMA has cooled to approximately 90 to 100°C depending on binder type.

It is expected that the Contractor's documented procedure will include monitoring of mat temperature and/or density as the compaction process proceeds. In this respect, the use and interpretation of nuclear density measurements must take into account the effect of the high surface voids.

In the case of contracts which involve thin SMA overlays at multiple locations of relatively small dimension, the Principal may accept the Contractor's proposal to verify compaction on the basis of proven and verifiable procedure provided that the SMA is uniformly compacted in accordance with the Contractor's procedure which must be:

(a) demonstrated in a placement trial (in accordance with Clause 4.8.3) to be capable of achieving conformity to the compaction standard (in accordance with Clause 4.8.1) without segregation of binder and reduction of surface texture.

(b) documented in the PROJECT QUALITY PLAN and addresses in detail:

  (i) acceptable pavement and weather conditions

  (ii) equipment type, condition, numbers and operation

  (iii) operator training and experience

  (iv) rolling patterns (including joints)

  (v) layer thickness and rolling temperature limitations

  (vi) contingency in case of breakdown or change in ambient conditions

In this case, the Principal is expected to ensure that the compaction regime is re-verified by placement trial as being capable of achieving the compaction standard whenever a condition or circumstance arises which may impact on the effectiveness of the compaction regime (refer 'b' above).

Clause 4.9 Joints

Maximisation of joint density will generally involve rigorous adherence to a procedure which includes:

(a) Ensuring that the edge of the first laid mat is a straight line or uniform curve which may readily be followed in placing and compacting the adjacent mat. Trimming of poorly aligned sections prior to placing the adjacent mat is desirable.

(b) Ensuring that the edge of the first laid mat is not rolled over or tapered in thickness (such as may occur with poor adjustment of paver screed extensions).

(c) Removal by trimming of cracked or bony edges of the first laid mat. This problem tends to occur more in coarse mixes at unsupported edges if inappropriate rolling techniques are used.

(d) Paving the second mat with appropriate compaction allowance and limited screed overlap onto the first laid mat. Good paver steering is thus important and the driver should be provided with premarked drivelines to follow for all paving runs.

(e) Tidying up the overlap with lutes where necessary and discarding rather than broadcasting excess material.

(f) Compacting the joint by progressively increasing overlap of the roller drum onto the new mat before compacting the remainder of the mat.

(g) Managing temperature/density of the mat throughout the process.

Clause 4.10 Homogeneity

It is intended that all pavement materials be homogeneous within their respective layers in the pavement and so it is with SMA. In the case of SMA, care should be taken not to confuse relatively coarse surface texture with lack of homogeneity.

A bony surface is one where it is apparent that a high concentration of large aggregate has been caused by poor handling process and it tends to occur in localised areas adjacent to joints and edges, at the start/finish of a truck load or in line with the centre of the paver screed if proper process is not employed. Poor hand raking is one of the major causes of a bony surface but failure to address issues of aggregate segregation may also result in a bony surface.

Clause 5 Finished Pavement Properties

Under this specification, SMA is not intended to be paved to survey levels.

Clause 5.1 Course Thickness

It should be noted that Clause 5.1(a) does not specify an upper limit for average compacted course thickness. This is because ride quality is generally a very high priority and there is no control over the profile of the existing pavement and no correction layer. If an upper limit is specified in inappropriate circumstances, there may be a tendency for the Contractor to 'chase' an average thickness as the job progresses rather than optimise ride quality.

In normal circumstances where no upper limit is specified, Project Managers must remain aware of the risks associated with inconsistent business arrangements between the various parties involved in providing the asphalt/pavement (eg purchasing in tonnes vrs sq metres, lump sum vrs schedule of rates).

In circumstances where Project Managers consider that average course thickness should be constrained within limits, the following wording may be added to the end of Clause 5.1(a):

> "..... nor greater than the specified course thickness plus the tolerance shown in Table R121.6 for the nominal size of SMA."

Notwithstanding the above, attention is drawn to the guide notes on Clause 4.4.

If, as provided for in the notes on Clause 4.8, compaction is not determined on the basis of cores then average course thickness of a lot must be determined by calculation on the basis of:

(a) age bulk density of laboratory compacted air voids samples for the lot, AS 2891.2.2, AS 2891.7.3, AS 2891.8, AS 2891.9.2 at 80 or 120 cycles of compaction (as specified in Annexure R121/A).

(b) of SMA paved in the lot.

(c) of the Lot.

Clause 5.3 Ride Quality

The cost/benefit of measuring ride quality warrants consideration depending on the nature of the works (eg major projects vrs intersections).

Assessment in respect of SMA overlays requires measurement of ride quality before and after the work and RMS Project Managers have an option to require the Contractor to conduct both measurements. The alternative is for RMS to provide ride quality measurement of the existing

pavement to tenderers. In all cases, ride quality information should be reported and assessed for each 100m interval or part thereof and not as an average figure for the job.

Clause 5.4 Skid Resistance

When first laid and depending on binder type, SMA may exhibit relatively low skid resistance until the binder/mastic is worn off the surface of the aggregate particles which contact vehicle tyres.

An interim solution which has been used in the past is the spreading of coarse sand on the surface prior to trafficking but it must be recognised that this procedure may have an adverse effect on surface texture depth and requirement in regard to environmental protection.

Clause 6.1 Rectification or Replacement

Rectification or replacement of relatively minor nonconformities in quality and/or workmanship may present unacceptable practical difficulties and acceptance of a suitable disposition by the Contractor may prove to be a better option overall. One such possibility may include a form of extended warranty.

Notwithstanding the above, any proposal by the Contractor to extend the Period of Post-Completion Undertaking in a disposition:

(a) should give assurance that:

  (i) there are adequate procedures and resources to monitor the works and rectify defects;

  (ii) any failure arising from the nonconformity will become apparent during the Period of Post-Completion Undertaking; and,

  (iii) after the extended Period of Post-Completion Undertaking, the life of the work will not be reduced by the nonconformity.

(b) should not increase the net costs of administering the Contract during the extended Period of Post-Completion Undertaking, including costs of:

  (i) quarantining the works from other works that are the responsibility of the RMS,

  (ii) directing repairs;

(c) should not increase the costs of maintaining the works after Completion;

(d) should provide an appropriate retention of Security Deposit.

The proposal should be referred to Infrastructure Contracts Branch.

Annexure R121/A Details of Work

Project Managers must ensure that this annexure is fully completed prior to issue of this document for procurement purposes.

Transport Roads & Maritime Services

QA SPECIFICATION R121

STONE MASTIC ASPHALT

IC-QA-R121

VERSION FOR:
DATE:

CONTENTS

CLAUSE PAGE

FOREWORD III
RMS Copyright and Use of this Document iii
Revisions to Previous Version iii
Project Specific Changes iii

1 GENERAL 1
1.1 Scope 1
1.2 Structure of the Specification 1

2 SUPPLY OF SMA 2
2.1 Materials for SMA 2
2.2 Quality Requirements for SMA 5
2.3 Nominated Mixes 7
2.4 Production of SMA 9
2.5 Sampling and Testing SMA 9
2.6 Transport 10

3 PREPARATION OF PAVEMENT 10

4 PLACING SMA 11
4.1 General 11
4.2 Protection of Work 11
4.3 Protection of Services and Road Fixtures 11
4.4 Course and Layer Thickness 11
4.5 Temperature and Weather Conditions 11
4.6 SMA Temperature for Laying 12
4.7 Tack Coat 12
4.8 Compaction 12
4.9 Joints 13
4.10 Homogeneity 14

5 FINISHED PAVEMENT PROPERTIES 14
5.1 Course Thickness 14
5.2 Shape 15
5.3 Ride Quality 15
5.4 Skid Resistance 16

6 NONCONFORMITY 16
6.1 General 16
6.2 Acceptance of Nonconformities 16

ANNEXURE R121/A – PROJECT SPECIFIC REQUIREMENTS 18

ANNEXURE R121/B – MEASUREMENT AND PAYMENT 19
B1 Measurement and Payment 19

ANNEXURE R121/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS 21
C1 Schedule of Hold Points and Witness Points 21
C2 Schedule of Identified Records 21

ANNEXURE R121/D – PLANNING DOCUMENTS 22

ANNEXURE R121/E – COMBINED PARTICLE SIZE DISTRIBUTION CHART 25

ANNEXURES R121/F TO R121/K – (NOT USED) 27

ANNEXURE R121/L – MINIMUM FREQUENCY OF TESTING 27
L1 Aggregates 27
L2 Filler 28
L3 Production SMA 29
L4 Placing SMA 29
L5 Insitu SMA 29

ANNEXURE R121/M – REFERENCED DOCUMENTS 30

LAST PAGE OF THIS DOCUMENT IS 31

FOREWORD

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When this document forms part of a contract

This document should be read with all the documents forming the Contract.

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REVISIONS TO PREVIOUS VERSION

This document has been revised from RMS Specification R121 Edition 2 Revision 0.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes have been indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. ***Additional Text***.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. ~~Deleted Text~~.

RMS QA SPECIFICATION R121

STONE MASTIC ASPHALT

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for Stone Mastic Asphalt (SMA). It includes:

(a) design of SMA, including constituent materials, its design, production and transport;

(b) preparation of the pavement; and

(c) placing of SMA including application of tack coat, laying and rolling of asphalt.

Stone Mastic Asphalt is an asphalt manufactured with a high proportion of coarse aggregate and relatively low air voids.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of Annexures that detail additional requirements.

1.2.1 Details of Work

Details of work are shown in Annexure R121/A.

1.2.2 Resolution of Nonconformities, Measurement and Payment

The method of measurement and payment must comply with Annexure R121/B.

Acceptance of materials and work must be in accordance with Clause 6.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules detailed in Annexure R121/C list the **HOLD POINTS** and **WITNESS POINTS** that must be observed. Refer to Specification RMS Q for definitions of **HOLD POINTS** and **WITNESS POINTS**.

The records listed in Annexure R121/C are **Identified Records** for the purposes of RMS Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure R121/D and must be implemented.

If the Contract does not require you to implement a PROJECT QUALITY PLAN, the documents listed in Annexure R121/D must be submitted to the Principal for consideration at least 5 working days prior to work commencing and must be implemented.

In all cases where this Specification refers to the Manufacturer's recommendations, these must be included in the PROJECT QUALITY PLAN.

1.2.5 Reference Documents and Definitions

Unless otherwise specified the applicable issue of a reference document, other than an RMS Specification, must be the issue current at the date one week before the closing date for tenders, or where no issue is current at that date, the most recent issue.

Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 2350). For convenience, the full titles are given in Annexure R121/M.

The terms "you" and "your" mean "the Contractor" and "the Contractor's" respectively.

In this specification, SMA may also be referred to as 'asphalt'.

2 SUPPLY OF SMA

Design and supply the product within the limits of the Specification to exhibit the following performance properties:

(i) durability in resistance to ravelling, rutting, stripping and flushing or bleeding;

(ii) substantial texture depth to assist in providing skid resistance and reducing spray generation;

(iii) relatively low permeability.

Comply with APRG 18, AS 2150 and AS 2734 for procedures not specified in this Specification.

2.1 MATERIALS FOR SMA

2.1.1 Coarse Aggregates

Coarse aggregates must conform to the requirements of AS 2758.5 subject to the following options and exceptions:

(a) Grading requirements:

The nominated grading of each constituent aggregate must conform to the SMA manufacturer's specification which must be attached to the PROJECT QUALITY PLAN. Allowable tolerances must not exceed Table 1 of AS 2758.5.

In addition to the above requirement, determine material finer than 75 μm and report in accordance with AS 1141.12.

(b) Shape:

Shape must conform to the requirements for 'particle shape' except that the proportion of misshapen particles using 2:1 ratio must not exceed 25 percent.

(c) Crushed particles of coarse aggregate:

Substitute test method RMS T239 for test method AS 1141.18.

When tested in accordance with RMS T239, the test portion of the aggregate must consist of:

(i) at least 85 per cent by mass of particles with at least two fractured faces where the combined fractured surface area is judged to be about one half or more of the total surface area of the particle; and

(ii) not less than 100 per cent by mass of particles with at least one fractured face where the area of the fractured face on those particles with only one fractured face is judged to be one quarter or more of the total surface area of the particle.

(d) Durability:

Durability of aggregates must conform to the requirements for wet strength and wet/dry strength variation.

(e) Resistance to stripping:

In lieu of the requirement of Clause 4 (b) of AS 1141.50, conduct the test using Class C170 binder conforming to AS 2008.

(f) Frictional characteristics:

When determined in accordance with AS 1141.41 and AS 1141.42, the polished aggregate friction value (PAFV) must not be less than the value specified in Annexure R121/A.

(g) Water absorption:

When determined in accordance with AS 1141.6.1, the water absorption of coarse aggregate of any nominal size must not exceed 2.5%.

2.1.2 Fine Aggregates

Fine aggregates must be material having nominal size of 5mm or less and must be one or a combination of the following:

(a) (i) aggregate; and/or

(ii) secondary and/or tertiary crusher dusts (such crusher dusts may be washed and/or classified prior to use in SMA),

resulting from the manufacture of coarse aggregates conforming to Clause 2.1.1;

or

(b) natural sands.

Fine aggregates must also conform to the following requirements:

(a) Grading requirements:

The nominated grading of each fine aggregate must conform to the SMA manufacturer's specification which must be attached to the PROJECT QUALITY PLAN. Allowable tolerances must not exceed Table 1 of AS 2758.5.

In addition to the above requirement, determine and report material finer than 75 μm in accordance with AS 1141.12 for each fine aggregate.

(b) Angularity:

When determined in accordance with AASHTO T 304-96 Method 'A', the uncompacted void content of the combined fine aggregate must not be less than 43.

(c) Water absorption:

When determined in accordance with AS 1141.5, the water absorption of a fine aggregate of any nominal size from any source must not exceed 3.5%.

(d) Soundness:

When determined in accordance with AS 1141.24, the weighted percent loss from a fine aggregate must not exceed 12% of the test portion.

(e) Reactivity of fine material:

The Methylene Blue Value (MBV) of the portion of a fine aggregate passing 0.075 mm AS sieve by AS 1141.11 must be determined and reported in accordance with International Slurry Surfacing Association Technical Bulletin No. 145.

2.1.3 Added Fillers

Added fillers, including baghouse dust, must conform to the requirements of AS 2357 subject to the following options and exceptions:

(a) Hydrated lime:

Hydrated lime must conform to the requirements of RMS 3211.

(b) Flyash:

Flyash must conform to RMS 3211 and must be “fine grade” in Table 1 of AS 3582.1.

(c) Reactivity of fine material:

For each rock flour and baghouse dust, determine and report the Methylene Blue Value (MBV) of the portion of material passing 0.075mm AS sieve by AS 1141.11 in accordance with International Slurry Surfacing Association Technical Bulletin No. 145.

2.1.4 Binder

The class of binder to be used in SMA must be as specified in Annexure R121/A and the binder must conform to RMS 3252 or RMS 3253 as appropriate for the binder specified.

Provide documentary evidence of the binder conformity for each delivery used in the work.

Polymer modified binder or multigrade binder must be selected for SMA.

2.1.5 Additives

(a) Bitumen Adhesion Agent:

Any added bitumen adhesion agent must conform to the requirements of RMS 3259 or RMS 3269 except that:

(i) substitute test method AS 1141.50 for test method RMS T230, and

(ii) in all cases, the binder used to conduct the test must be Class C170 conforming to AS 2008.

(b) Fibre Additive:

Fibre additive must be cellulose fibre and you must select a suitable source.

You may propose and use, subject to the Principal's approval, an alternative fibre additive provided that you submit documented evidence of successful use or trial of such fibre additive under circumstances similar to those which exist under the Contract.

In all cases, the technical specification for the fibre additive and manufacturer's recommendations on the application, handling and incorporation of the fibre additive into asphalt must be attached to the PROJECT QUALITY PLAN.

2.1.6 Bitumen Emulsion Tackcoat

Bitumen emulsion tackcoat must be CRS/170-60 conforming to the requirements of AS 1160.

If specified in Annexure R121/A, the bitumen emulsion tackcoat must contain a minimum of 3% SBR polymer modifier.

Nominate in the PROJECT QUALITY PLAN the class of binder in the emulsion and any proposed modification to the binder.

2.2 QUALITY REQUIREMENTS FOR SMA

2.2.1 Proportions of Constituents

(a) **Fine aggregate**: A minimum of 50% of the fine aggregate constituent(s) in SMA must be derived from crushed hard rock quarry material.

(b) **Hydrated Lime**: The SMA must contain, by mass of the combined particle size distribution, a minimum of 1.5% of powdered hydrated lime complying with Clause 2.1.3.

(c) **Fibre Additive**: Subject to the provisions of Clause 2.1.5 (b), the SMA must contain (% by mass of total SMA mix) a minimum of 0.3% of cellulose fibre additive.

(d) **Adhesion Agent**: A bitumen adhesion agent may be added to the binder.

(e) **Binder**: When determined in accordance with AS 2891.3.1, the binder content of SMA mix (% by mass of total SMA mix) must be within the range specified in Table R121.1.

Table R121.1 - Binder Content

Nominal Mix Size	Binder Content Limits
10mm	≥ 6.2% to ≤ 7.2%.
14mm	≥ 6.0% to ≤ 7.0%.

2.2.2 Combined Particle Size Distribution

The combined particle size distribution of the nominated mix, when determined in accordance with AS 2891.3.1, must conform to the requirements of Table R121.2.

Table R121.2 - Combined Particle Size Distribution

AS Sieve Size (mm)	Combined Aggregate and Filler Design Limits Percent Passing (by mass)	
	10 mm SMA	**14 mm SMA**
19.0	100	100
13.2	100	84 – 100
9.50	84 – 100	35 – 60
6.70	35 – 60	20 – 40
4.75	20 – 40	19 – 31
2.36	16 – 28	16 – 28
1.18	14 – 24	14 – 24
0.600	11 – 21	11 – 21
0.300	10 – 18	10 – 18
0.150	9.0 – 15.0	9.0 – 15.0
0.075	8.0 – 12.0	8.0 – 12.0

2.2.3 Voids in SMA

Voids in laboratory compacted SMA (% voids of the volume of the SMA mix), when compacted in accordance with AS 2891.2.2 and tested in accordance with AS 2891.7.3, AS 2891.8 and AS 2891.9.2, must conform to the requirements of Table R121.3.

Table R121.3 - Voids in Laboratory Compacted SMA

Loading Category	Cycles of Compaction (as specified in Annexure R121/A)	10 mm SMA	14 mm SMA
Normal	80	5.0% ± 1.5%	5.0% ± 1.5%
	350	> 2.0%	> 2.0%
Heavy	120	5.0% ± 1.5%	5.0% ± 1.5%
	350	> 2.5%	> 2.5%

Determine and report voids in mineral aggregate (VMA) at 80 or 120 cycles of compaction (as specified in Annexure R121/A) in accordance with AS 2891.8.

The dry compacted voids of the fraction of mineral matter passing a 0.075mm AS sieve must not be less than 40% in accordance with AS 1141.11 and AS 1141.17.

Roundabouts and all roads with speed restriction must be considered as "heavy" loading category.

2.3 NOMINATED MIXES

2.3.1 Submission of Nominated Mixes

Submit to the Principal at least one nominated mix. The submission must include the following details:

(a) Constituent materials

(i) Aggregates - source, geological type.

(ii) Filler - type and source.

(iii) Binder - source, class or grade.

(iv) Bitumen Adhesion Agent - name, type, source of supply.

(v) Fibre Additive - type and source.

(vi) Bitumen emulsion tackcoat - class of bitumen, any bitumen modification, source.

(vii) Relevant test results verifying material properties specified in Clause 2.1 for the above mentioned materials.

(b) SMA Design

(i) Proportion of each constituent by percentage of mass of total SMA mix.

(ii) Test Record (verification) Forms showing a nominated value and allowable tolerances for each SMA quality requirement in Clause 2.2. Include each sieve of the combined particle size distribution.

(iii) Type and identification number of asphalt mixing plant..

(c) Submit test results of the following properties of a trial batch of each nominated mix produced by the mixing plant from which the SMA is to be supplied.

(i) Combined Particle Size Distribution, AS 2891.3.1, for all sieves listed in Table R121.1.

(ii) Binder Content, by mass of total mix, AS 2891.3.1.

(iii) Voids in the laboratory compacted mix and voids in mineral aggregate at cycles of compaction specified in Annexure R121/A, expressed as per cent by volume, AS 2891.2.2, AS 2891.7.3, AS 2891.8 and AS 2891.9.2.

(iv) Dry compacted voids in the fraction of mineral aggregate passing 0.075 AS sieve in accordance with AS 1141.11 and AS 1141.17.

The required testing must have been carried out within the twelve month period prior to the date of submission to the Principal. All tests for each nominated mix must be from one trial batch and tests of the constituent materials must represent the materials used in this trial batch. Perform all phases of any particular test at one laboratory.

Report the nominated combined particle size distribution and VMA in accordance with Annexure R121/E.

(d) A statement, signed by you stating that each SMA mix and its constituents meet the requirements of Clauses 2.1 and 2.2. Include NATA Endorsed test results for all specified tests in your statement. Attach a copy of your completed verification checklist.

HOLD POINT	
Process Held:	Use of each nominated mix
Submission Details:	Documents as detailed in clause 2.3.1 at least 7 working days before each asphalt mix is proposed to be used.
Release of Hold Point:	The Principal will consider the submitted documents, prior to authorising the release of the Hold Point.

2.3.2 Tolerances for Nominated Mixes

Tolerances for the trial and production mixes will be permitted, for the actual binder content from the nominated binder content and the actual combined aggregate particle size distribution from the nominated aggregate particle size distribution, within the limits shown in Table R121.4.

Table R121.4 - Tolerances for SMA

Description	Tolerance
Production tolerances for the actual combined particle size distribution from the nominated combined particle size distribution during trial and production (% by mass of total aggregate, AS 2891.3.1) for each mix size:	
Pass 4.75 mm and larger	± 7
Pass 2.36 mm and 1.18 mm	± 5
Pass 0.600 mm and 0.300 mm	± 4
Pass 0.150 mm	± 2.5
Pass 0.075 mm	± 1.5
Production tolerance for the actual binder content from the nominated binder content during production (% by mass of total asphalt mix, AS 2891.3.1)	± 0.3

2.3.3 Variations to Nominated Mix

If you propose to vary:

(a) the proportions of the constituents in a nominated mix , with the exception of added filler, by 10% or more of the value nominated in accordance with Clause 2.3.1(b)(i); or

(b) the proportion of added filler by 15% or more of the value nominated in accordance with Clause 2.3.1(b)(i); or

(c) values nominated in accordance with Clause 2.3.1(b)(ii); or

(d) any constituent source including binder,

then submit a new nominated mix in accordance with Clause 2.3.1.

2.4 PRODUCTION OF SMA

2.4.1 Methods of Production

Your methods of production must be such as to:

(a) control the process and target the nominated mix; and

(b) supply a homogeneous product.

2.4.2 Plant

The production plant must have and you must allocate sufficient capacity to supply SMA for continuous operation of the paver.

2.4.3 Storage and Handling of Binder and SMA

Implement procedures for storage and handling of binder which ensure prevention of segregation and contamination of the binder by flushing liquids or other materials.

At the asphalt manufacturing plant, recirculate binder covered by Specification RMS 3252 in delivery and/or storage tanks to a uniform consistency prior to use in the asphalt. In addition to this requirement, clearly demonstrate adherence to the binder manufacturer's written recommendations in regard to storage times and storage temperatures (refer to Clause 1.3).

Do not retain SMA in hot storage silos prior to use except for that period of time necessary to minimise segregation during loading of trucks.

2.4.4 Temperatures of Materials

Control temperatures of constituent materials by suitable thermometer elements placed in the flow of materials from the drier and in the binder storage system or binder supply line. The difference in temperature between binder and aggregate must not exceed 30°C at the point of mixing.

Thermometer registrations must be readable and accurate to within plus or minus 2°C.

In accordance with a documented procedure, nominate in the PROJECT QUALITY PLAN the range of temperatures within which the binder and SMA will be maintained for the manufacturing process.

Measure the SMA temperatures as the SMA leaves the pugmill or drum and the hot storage bin(s) or on the trucks prior to leaving the plant.

2.5 SAMPLING AND TESTING SMA

2.5.1 Sampling

Sample the SMA at either the point of loading or the point of delivery to the work.

Undertake sampling of each nominal size of asphalt supplied in accordance with AS 2891.1 and at the frequencies nominated in the PROJECT QUALITY PLAN.

Further to the requirements of RMS Q, Clause 7.5.3 and Annexure Q/L and unless otherwise specified or agreed with the Principal, boundaries of Lots represented by a single tested sample are defined by the midpoints in production between the sample points.

When obtaining samples and when requested by the Principal, provide samples to the Principal, from the same Lot by riffling or quartering your own samples.

2.5.2 Testing

Test SMA supplied for the for the purpose of verifying conformity to specification.

Complete tests for binder content, combined particle size distribution, voids in laboratory compacted mix and VMA and report to the Principal within 1 working day of mixing. Complete tests for insitu air voids, compacted course thickness and shape and report to the Principal within 3 working days of placing the SMA.

2.5.3 Minimum Frequency of Testing

Nominate in your Project Quality Plan the proposed testing frequency which must not be less than that specified in Annexure R121/L. Where a minimum frequency is not specified, nominate an appropriate frequency. Table R121.5 will apply when referred to in Annexure R121/L.

Table R121.5 - Minimum Frequency of Testing of SMA

Quantity of SMA supplied each Shift	Minimum Frequency of Testing
Less than 100 tonnes	One per 50 tonnes or part thereof
101 to 300 tonnes	One per 100 tonnes or part thereof
301 to 600 tonnes	One per 150 tonnes or part thereof
Over 600 tonnes	One per 200 tonnes or part thereof
Note: For the purpose of this Minimum Frequency of Testing clause, a "shift" must be continuous work not exceeding a period of 12 hours.	

The Principal may conditionally agree to your proposal to reduce the specified minimum frequency of testing. Support the proposal by a statistical analysis verifying consistent process capability and product characteristics. The Principal may vary or restore the specified minimum frequency of testing, either selectively or permanently, at any time.

2.6 TRANSPORT

Transport of SMA must comply with Section 6 of AS 2734.

3 PREPARATION OF PAVEMENT

Preparation of the pavement prior to placing asphalt must comply with Section 4 of AS 2734 and include removal of raised extruded thermoplastic road markings and raised pavement markers.

SMA must be placed on base with adequate load bearing capacity.

4 PLACING SMA

4.1 GENERAL

Place and finish SMA so as to:

(a) produce a homogeneous product with a sound surface;

(b) achieve the specified insitu air voids;

(c) achieve the finished pavement properties, specified in Clause 5, to the specified tolerances.

Place SMA by a self-propelled paving machine equipped with automatic grade/level/joint matching facility. Only use hand placement of SMA for minor correction of the existing surface and in areas where placement with a paver is impracticable.

WITNESS POINT

Process Witnessed:	Each placement trial and initial placing of each nominated mix
Submission Details:	Notification of the time, place and location at least 7 days prior to commencement

4.2 PROTECTION OF WORK

Provide for traffic in accordance with the requirements of Specification RMS G10 while undertaking the work and protect the work until the required thickness of SMA has been laid, compacted and cooled to a surface temperature of 40°C prior to initial opening to traffic.

Do not induce rapid cooling in the SMA by the application of water at any stage in the process, including preparations for trafficking, except where the SMA and/or its constituents are at a temperature less than 60°C.

4.3 PROTECTION OF SERVICES AND ROAD FIXTURES

Take all necessary precautions to prevent SMA or other material used on the work from entering or adhering to gratings, hydrants or valve boxes, manhole covers, bridge or culvert decks and other road fixtures. Immediately after the SMA has been placed, clean off or remove any such material.

4.4 COURSE AND LAYER THICKNESS

A course of SMA comprises one layer only.

4.5 TEMPERATURE AND WEATHER CONDITIONS

Measure and record pavement surface temperature and wind velocity at the point of SMA laying.

Do not place SMA layers less than 45 mm specified thickness when:

(a) the pavement surface temperature is below 10°C.

(b) the pavement surface temperature is below 25°C and the velocity of the wind across the pavement exceeds 15 kilometres per hour.

Do not place SMA layers less than 30 mm specified thickness when:

(a) the pavement surface temperature is below 10°C.

(b) the pavement surface temperature is below 25°C and the velocity of the wind across the pavement exceeds 5 kilometres per hour.

Do not place SMA when the surface of the pavement is wet or while rain appears imminent.

4.6 SMA TEMPERATURE FOR LAYING

Measure the temperature of SMA immediately prior to placing. Use a suitable stem type thermometer readable and accurate to within plus or minus 2°C with a range from at least 0°C to 200°C. Insert the stem into the SMA to a depth of approximately 200 mm at a location at least 300 mm from the side of the truck body. Adopt the average of two readings as the temperature of the SMA.

Do not use in the work that part of any truck load which contains lumps of cooled SMA which are liable to affect the quality of the finished surface.

In accordance with a documented procedure, nominate in the PROJECT QUALITY PLAN the range of temperatures within which the paving of the SMA will be completed.

4.7 TACK COAT

Determine the suitable application rate of residual bitumen which must be between 0.15 and 0.3 litres per square metre. Notify the proposed application rates in writing to the Principal seven days prior to commencement of application of tack coat.

Evenly spread the tackcoat over the surface to be tack coated and apply at the nominated application rate $\pm$ 0.2 L/m^2. Do not damage the tackcoat prior to placing of the asphalt layer.

Endorse and provide to the Principal, a record of the average tack coat application rate in each Lot.

4.8 COMPACTION

4.8.1 Compaction Standard

The compaction standard for SMA is as follows:

(a) Carry out compaction control on the Lot using statistical techniques as specified in RMS Q.

(b) Conformity of the Lot is achieved if, when determined in accordance with Clause 4.8.2, the lower characteristic value of insitu air voids (V_L) for that Lot is not less than 4% and the upper characteristic value of insitu air voids (V_U) for the Lot is not more than 9%.

Report insitu air voids to the nearest 0.1% and assess for conformity after rounding to the nearest 1%.

Do not subject SMA placed to specified layer thickness less than 30 mm to the compaction standard.

4.8.2 Determination of Insitu Air Voids

Determine characteristic values of insitu air voids of the Lot on the basis of cores.

The calculation of the upper and lower Characteristic Values of Insitu Air Voids (V) of a Lot must be as follows:

$V_U = \bar{a} + ks$ $V_L = \bar{a} - ks$

where: x is the relative compaction of the core

a is the sub-lot attribute test result and equals (100-x)

$\bar{a}$ is the arithmetic mean of attribute test results for all sub-lots

s is the standard deviation of sub-lot attribute test results

k is as stated in RMS Q Annexure Q/L Table Q/L.2

The values of V must be rounded and reported to the nearest 0.1% and both x and s are expressed in percentage. Relative compaction of a core is the ratio of the bulk density of the core and the mean maximum density of the lot determined by AS 2891.9.2 and AS 2891.7.3 respectively and reported as a percentage of mean maximum density.

4.8.3 Placement Trial

Where specified in Annexure R121/A and prior to commencing work, subject your plant and personnel proposed for use on the job to a placement trial(s). Adhere to all procedures in the submitted PROJECT QUALITY PLAN.

The trial section must be at least 300 m in length and one lane in width and a maximum of one day's production. Each nominated mix is subject to a separate placement trial and the location of each trial is subject to the agreement of the Principal.

HOLD POINT

Process Held:	Commencement of placing SMA for each combination of materials, mix proportions, equipment, rate of paving and methods for placement, rolling and finishing.
Submission Details:	Verification checklist and all relevant test results of the trial section at least 3 working days prior to use of the nominated mix.
Release of Hold Point:	The Principal will consider the submitted documents and agree the trial location, prior to authorising the release of the Hold Point.

In the event of a nonconformity in the placement trial in respect of insitu characteristics, including compaction standard, course thickness, joint quality or riding quality or when the Principal deems that a previous trial does not represent the changes in the equipment, materials, SMA mix proportions, temperature, plant or rate of output, the Principal may direct a new trial.

4.9 JOINTS

Construct all joints following a procedure which maximises joint density and is documented in the PROJECT QUALITY PLAN. Finish each joint with a smooth, planar surface coinciding with the surface of the rest of the mat.

Locate longitudinal joints coincident with final traffic markings.

Form a transverse joint at the commencement of each paving run and when the asphalt being paved has cooled below the minimum temperature nominated in the PROJECT QUALITY PLAN for compaction.

4.10 HOMOGENEITY

A Lot contains only areas of work which are essentially homogeneous. Any surface areas which show bony or fatty material or have been damaged during construction will be deemed to be non-conforming and must be managed in accordance with Clause 6.

5 FINISHED PAVEMENT PROPERTIES

5.1 COURSE THICKNESS

(a) Single course work. When SMA is placed over an existing pavement constructed by others, the average compacted course thickness of each Lot must not be less than the specified course thickness as shown in Annexure R121/A.

(b) Multiple course work. When SMA is placed over an existing pavement on which at least one other intermediate or corrective course has been applied by you, a Lot will be deemed to have achieved conformity if the lower characteristic value of thickness (TL) for the Lot is not less than the specified course thickness shown in Annexure R121/A and the upper characteristic value of thickness (TU) for the Lot is not more than the specified course thickness plus the tolerance specified in Table R121.6.

Table R121.6 - Tolerance for Specified Course Thickness

Nominal Size of Asphalt (mm)	Tolerance (mm)
10	+ 6
14	+ 8

Determine characteristic values and average value of thickness of the Lot on the basis of cores and statistical techniques as specified in RMS Q.

The calculation of the upper and lower Characteristic Values of Thickness (T) for the Lot must be as follows:

$T_U = \bar{x} + ks$ $T_L = \bar{x} - ks$

where: x is the average height of a core based on measurements taken at four equidistant points at the circumference of the core.

$\bar{x}$ is the arithmetic mean of attribute test results for all sub-lots

s is the standard deviation of sub-lot attribute test results

k is as stated in RMS Q Annexure Q/L Table Q/L.2

The average value of thickness for the lot is $\bar{x}$.

Note $\bar{x}$, x and s are in mm and T is rounded to the nearest whole millimetre.

5.2 SHAPE

The surface must not deviate from the bottom of a 3 m long straightedge laid in any direction and at any point on the surface by more than the tolerances shown in Table R121.7.

Table R121.7 - Deviations from 3 m Straight-edge

Freeways & Rural Highways	Urban Highways & Other Classified Roads
3 mm	5 mm

Where required to provide a new wearing course in a single layer operation over a pavement constructed by others and the deviations of the existing surface from a 3 m straight-edge exceed the tolerance specified in Table R121.7, Table R121.7 does not apply at those locations. However, the measured deviation of the new surface must be less than that of the existing surface.

5.3 RIDE QUALITY

The finished surface must have a smooth longitudinal profile and, where specified in Annexure R121/A. The ride quality of the finished surface must be measured in terms of NAASRA Roughness with a Profilometer, (RMS T187) or a calibrated NAASRA (AUSTROADS) roughness meter vehicle (RMS T182).

Determine the roughness count from the average of three replica runs as follows:

(a) Divide each lane into sections 100 m long. Include any length less than 100 m with the section immediately preceding it and an average roughness determined for the section.

(b) Do not include the start and finish joints of the entire work in any section.

(c) Do not measure roundabouts under this Clause.

The NAASRA roughness count of each 100 m section must not exceed:

(i) a value of 40 counts per kilometre where construction of the underlying pavement forms part of the Contract; or

(ii) a value of 40 counts per kilometre where, excluding any corrective course, asphalt is placed in more than one layer, over a pavement constructed by others; or

(iii) the value (S) as specified below where you provide only one course, excluding any corrective course, in a single layer operation over a pavement constructed by others:

S = 40 counts/km or (A x 0.6) + 5 counts/km, whichever is the greater

where A = count prior to overlay

and S and A are reported to the nearest 1 count/km

Where specified in Annexure R121/A, determine and report the riding quality of the existing surface.

5.4 SKID RESISTANCE

If specified in Annexure R121/A, spread dry coarse sand conforming to Clause 2.1.2 over the surface at the rate of 0.6 to 0.9 kg/m^2 prior to completion of rolling. Remove excess sand from the pavement surface prior to completion of the working shift.

6 NONCONFORMITY

6.1 GENERAL

If a section of SMA fails to achieve conformity to specification, such failure will constitute a "Nonconformity" under the Contract.

If the nonconformity is not acceptable in accordance with Clause 6.2, rectify or replace the section of nonconforming SMA.

Use a method of rectification which avoids damage and does not affect the performance of structures such as underlying bound pavement layers, reinforced concrete, utilities, utility covers and similar structures. The cost of rectification, including any restoration work to the underlying or adjacent surface or structure, which becomes necessary as a result of such replacement or correction, must be borne by you. Replace SMA removed from the works with SMA conforming to the requirements of this Specification.

6.2 ACCEPTANCE OF NONCONFORMITIES

Nonconformities may be accepted by the Principal subject to deductions (as specified hereunder) to the schedule rate applied to the quantity of asphalt represented by the test sample for combined particle size distribution and binder content; and by 100m lane interval for riding quality.

Record deductions against Pay Item R121P3.

Other nonconformities may be accepted subject to the agreement of the Principal.

6.2.1 Combined Particle Size Distribution and Binder Content

For SMA having particle size distribution or binder content outside the limits specified in Clause 2.3.2, the deductions shown in Table R121.8 will apply and will be cumulative.

If the particle size distribution on any sieve size or the binder content varies from the nominated mix by more than twice the permissible variations specified in Table R121.3 or the combined deductions exceed 20 per cent, replace the SMA in accordance with Clause 6.1.

Table R121.8 - Deductions for Combined Particle Size Distribution and Binder Content

Description	Variations*	Deductions (per cent of schedule rates)
Combined Particle Size Distribution Element	**(% by mass of total aggregate)**	
Pass 13.2 mm AS sieve	Each 2 or part thereof	1
Pass 9.50 mm AS sieve	Each 2 or part thereof	1
Pass 6.70 mm AS sieve	Each 2 or part thereof	1
Pass 4.75 mm AS sieve	Each 2 or part thereof	1
Pass 2.36 mm AS sieve	Each 1 or part thereof	1
Pass 1.18 mm AS sieve	Each 1 or part thereof	1
Pass 0.600 mm AS sieve	Each 1 or part thereof	1
Pass 0.300 mm AS sieve	Each 1 or part thereof	2
Pass 0.150 mm AS sieve	Each 0.5 or part thereof	2
Pass 0.075 mm AS sieve	Each 0.5 or part thereof	2
Binder Content for	**(% by mass of total asphalt mix)**	
10 mm asphalt	Each 0.1 or part thereof	3
Note *Outside the production tolerance for the combined aggregate particle size distribution and binder content set out in Clause 2.3.2.		

6.2.2 Ride Quality

For sections having ride quality outside that specified in Clause 5.3, apply deductions in accordance with Table R121.9.

Table R121.9 - Deductions for Riding Quality

Roughness Count Rate above specified count (counts per kilometre)	Deduction per cent for the value of the section
1 – 5	2
6 – 10	4
11 – 15	8
16 – 20	16
> 20	Remove and replace
Note: Each section, for the purpose of calculating deductions, consists of the specified average course thickness along a traffic lane. When the Pay Item is measured in tonnes, apply a conversion factor of 2.4 tonnes per cubic metre.	

ANNEXURE R121/A – PROJECT SPECIFIC REQUIREMENTS

Contract Number _____

Pavement Type _____

General Location _____

Specific location of SMA to be paved	**Nominal Size of SMA Material (mm)**	**Compacted course thickness (mm)**	**Binder Type** (Clause 2.1.4)	**Laboratory compaction cycles** (Clause 2.2.3)

Clause	**Description**	**Require-ment ***
2.1.1(f)	Minimum PAFV of Coarse Aggregate for wearing course	
2.1.4	***Polymer modified or Multigrade Binder used*** ***NB: Polymer Modified Binder or Multigrade Binder must be selected for SMA***	***Yes / No***
2.1.6	Polymer modifier in bitumen emulsion tackcoat	Yes / No
4.8.3	Placement trial required	Yes / No
5.3	Ride quality of existing surface to be measured	Yes / No
5.3	Ride quality of finished surface to be measured	Yes / No
5.4	Dry coarse sand to be spread on surface	Yes / No

* Insert value or delete as applicable

Measure the following pay items by area (Annexure R121/B):

ANNEXURE R121/B – MEASUREMENT AND PAYMENT

B1 MEASUREMENT AND PAYMENT

Payment for the activities associated with completing the work detailed in this Specification will be made in accordance with the following Pay Items.

A lump sum price for any of these items will not be accepted.

Where an item of work required is not specifically covered by the measurement and payment descriptions for the pay items in the Schedule, due allowance must be made in one or more of the other pay items to allow for this item of work.

Measurement and Payment of asphalt is made on the basis of either mass or area as follows:

(a) Measurement by Mass:

Unless it is specified otherwise in Annexure R121/A, the quantity of SMA must be measured by mass and the unit of measurement must be per tonne.

The quantity of SMA in place in the final work must be determined by the Principal from truck weighbridge dockets supplied by you and issued at a weighbridge certified by the NSW Government Department of Fair Trading and collected at the point of delivery unless measurement by batch weight using certified scales is approved by the Principal.

Include a separate pay item for SMA in the Schedule of Rates for each specified course thickness and binder type.

(b) Measurement by Area:

If so specified in Annexure R121/A, measure the quantity of tack coat used and/or the quantity of SMA by area and the unit of measurement must be per square metre.

Determine the area from the dimensions of the plan surface shown on the Drawings or as specified for the work being measured.

Include a separate pay item for SMA in the Schedule of Rates for each specified course thickness and binder type.

Pay Item R121P1 - Preparation of Surface

R121P1.1 Preparation of surface

The unit of measurement is the square metre.

Pay Item R121P2 - Supply, Deliver and Lay SMA Asphalt (including tackcoat)

R121P2.1 10 mm Nominal Size

R121P2.2 14 mm Nominal Size

Pay Item R121P3 - Deductions in Accordance with Clause R121.6.2

R121P3.1 Combined Particle Size Distribution and Binder Content

R121P3.2 Riding Quality

Deductions made under this pay item will not be subject to rise and fall adjustments.

ANNEXURE R121/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

Clause	Type	Description
2.3.1	Hold	Use of each nominated mix.
4.1	Witness	Each placement trial and initial placing of each nominated mix.
4.8.3	Hold	Commencement of placing trial SMA.

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of RMS Q Annexure Q/E.

Clause	Description of Identified Record
2.1.4	Documentary evidence of the binder conformity for each delivery.
2.3.1	Documents as detailed for each nominated asphalt mix.
2.5.2	Reports on tests for binder content, combined particle size distribution, voids in laboratory compacted mix and VMA.
2.5.2	Reports of tests for insitu air voids, shape and compacted course thickness.
4.7	Proposed application rates for tack coat.
4.7	Average tack coat application rate in each Lot.
4.8.3	Verification checklist and all relevant test results of the trial section of each combination of materials, mix proportions, equipment, rate of paving and methods for placement, rolling and finishing.

ANNEXURE R121/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4. The following documents are a summary of documents that must be included in the PROJECT QUALITY PLAN. Review the requirements of this Specification and others included in the Contract to determine additional documentation requirements.

Key Project Quality Planning Action Points to be shown in the Inspection and Test Plan (and Checklists) and implemented, also additional requirements to be included in project quality planning documents:

H = Hold Point Release I = Inspection Point J = Joint Inspection Point

M = Measurement Point for payment N = Notice to Principal T = Test Point

R = Additional requirements to be shown in the Project Quality Plan W = Witness Point

Clause	Description	Action Point
	General	
RMS Q	Definition of lot for each step of the process	R
RMS Q	Include procedures for management of each lot to completion of the Contract in the Project Quality Plan	R
RMS Q	Include details of verification and endorsement procedures in the Project Quality Plan	R
RMS Q	Storage and availability of conformity records	R
RMS Q	Subcontractors quality plans assessed and audit procedure established	R
1	Account taken of specification intent	R
1.2.4	Relevant technical references held on Site	I
1.3	Details of all procedures, construction methods, manufacturing plant and machinery, technical equipment, Project staff, manufacturer's written recommendations and statistical techniques	R
RMS Q	Procedure for the identification and implementation of corrective action	R
1.3	List of all documents to be held on Site	R
	Supply of Asphalt	
2.1.1	Coarse aggregate properties conform	I, T
2.1.2	Fine aggregate properties conform	I, T
2.1.3	Filler properties conform	T
2.1.4	Binder properties conform	T
2.1.5	Bitumen adhesion agent properties conform	T
2.1.5	Fibre Additive nominated and details attached to PROJECT QUALITY PLAN	R
2.1.6	Bitumen emulsion tack coat conforms.	T, R
2.2	SMA mix conforms	I, T

Clause	Description	Action Point
2.3.1	Submission of Nominated Mix constituent materials, mix design and test results and verification (7 days notice) NOTE: Hold Point applies	N
2.3.1	Hold Point on submitted Nominated Mix has been released	I, H
2.3.2	Production tolerances noted	R
2.3.3	Procedure to identify need for submission of new nominated mix	R
RMS Q	Procedures for handling and storing materials for asphalt	R
2.4.1	Procedures for the manufacture of asphalt including targeting of the nominated mix and control of the process	R
2.4	Procedure for storage of asphalt	R
2.4	Details of manufacturing plant including calibration	R, T
2.4.3	Procedures for storage and handling of binder established. Storage temperatures and storage times documented	R
2.4.3	Storage tank contents recirculated	I
2.4.4	Details of thermometers including calibration	R, T
2.4.4	Process temperatures ranges included to Project Quality Plan	R
2.5.2	Procedure including timeframe for submission of test results	R
2.5.3	Schedule of sampling and testing established	R
	Placing	
2.6	Procedure for the transport of asphalt	R
3	Procedure for preparation of pavement including removal of existing markings	R
4.1, 1.3	Procedures for placing asphalt, tack coating, hand placed areas and rolling	R
4.1	Notify intention to commence placing asphalt or placement trial (7 days notice)	N, W
4.2	Traffic management procedures comply with RMS G10	R, I
4.2	Temperature of compacted mat monitored for initial opening to traffic. Arrangements for sanding if required.	R
4.3	Procedures for protection of services and road fixtures	R, I,
4.5	Include details of equipment and personnel for pavement surface temperature measuring and recording in the Project Quality Plan	R, I
4.5	Pavement temperature measured and conforming	T
4.5	Pavement surface is not wet and rain is not imminent	I
4.6	Details of asphalt temperature before discharge	R, I, T
4.7	Tack coating procedures established	I, N
4.7	Tack coat application rate is in accordance with that nominated	T
	Compaction	
4.8.1	Details of compaction methods established and documented	R

Clause	Description	Action Point
4.8.2	Insitu air voids of placement trial conform	T
4.8.3	Placement trial location advised by Principal	H
4.8.3	Placement trial hold point released	H
4.9	Procedure for construction of joints	R, I
4.10	Product is homogeneous	I
	Finished Pavement Properties	
5.1	Compacted course thickness: Areas measured, average bulk density of laboratory compacted samples determined, thickness conformity	I, T
5.2	Pavement shape conforms	I, T
5.3	Surface has smooth longitudinal profile, roughness count conforms	I, T
6	Nonconformity held, investigated and reported, dispositions accepted by Principal	I
6.1,RMS Q	Rectifications completed, Hold Point (where specified) is released	I, T, H
6.2	Acceptance of nonconforming combined particle size distribution, binder content and riding quality reported with proposed payment deduction calculations	M, N
RMS Q	Final inspection and all test results for each lot verified	I
7	Lot measurement agreed with Principal	J
Annex R121/A	Details of work incorporated in the Project Quality Plan	R

ANNEXURE R121/E – COMBINED PARTICLE SIZE DISTRIBUTION CHART

INSTRUCTIONS FOR PREPARATION OF ANNEXURE R121/E

1. Plot the following on the attached chart:
   (a) Nominated Combined Particle Size Distribution.
   (b) Control Points as required by the limits of Table R121.2.
   (c) Production tolerances of the nominated mix in accordance with Table R121.4.
   (d) The 0.45 power Fuller Curve by connecting the origin by a straight line to the sieve size immediately above the nominal mix size.

2. Record the Contract ID, Nominal Mix Size, Mix Type, VMA, and Date in the space provided.

An example of the completed chart is shown in Figure R121.1 below:

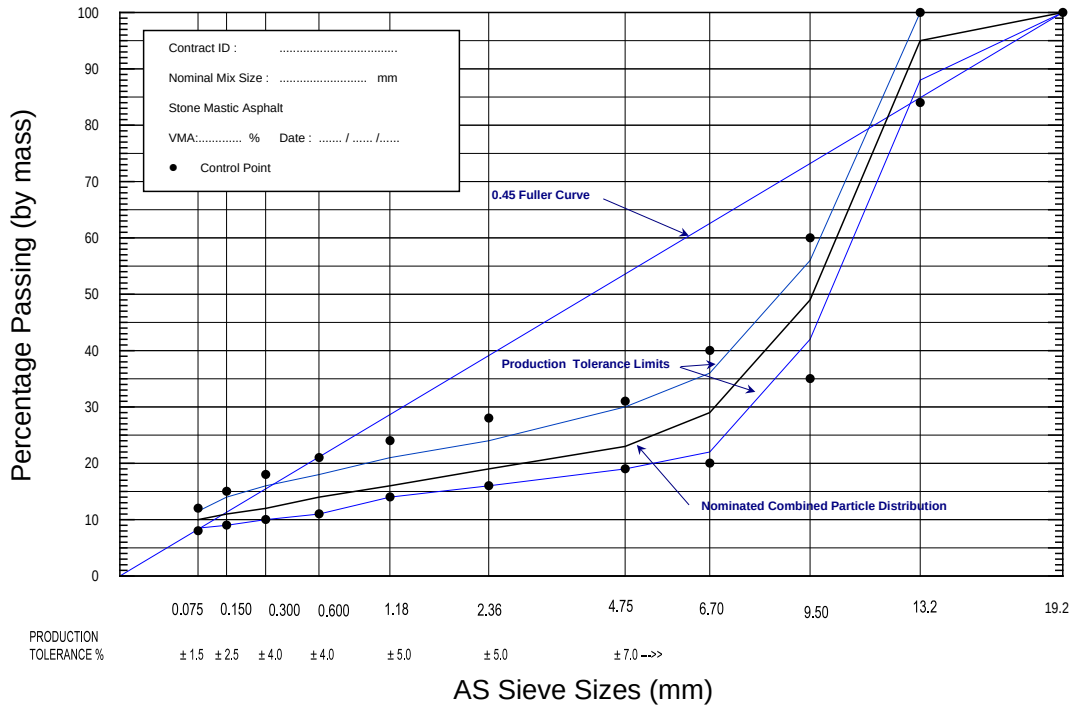

Figure R121.1 - Combined Particle Size Distribution - 14 mm SMA

R121_F1.PRS

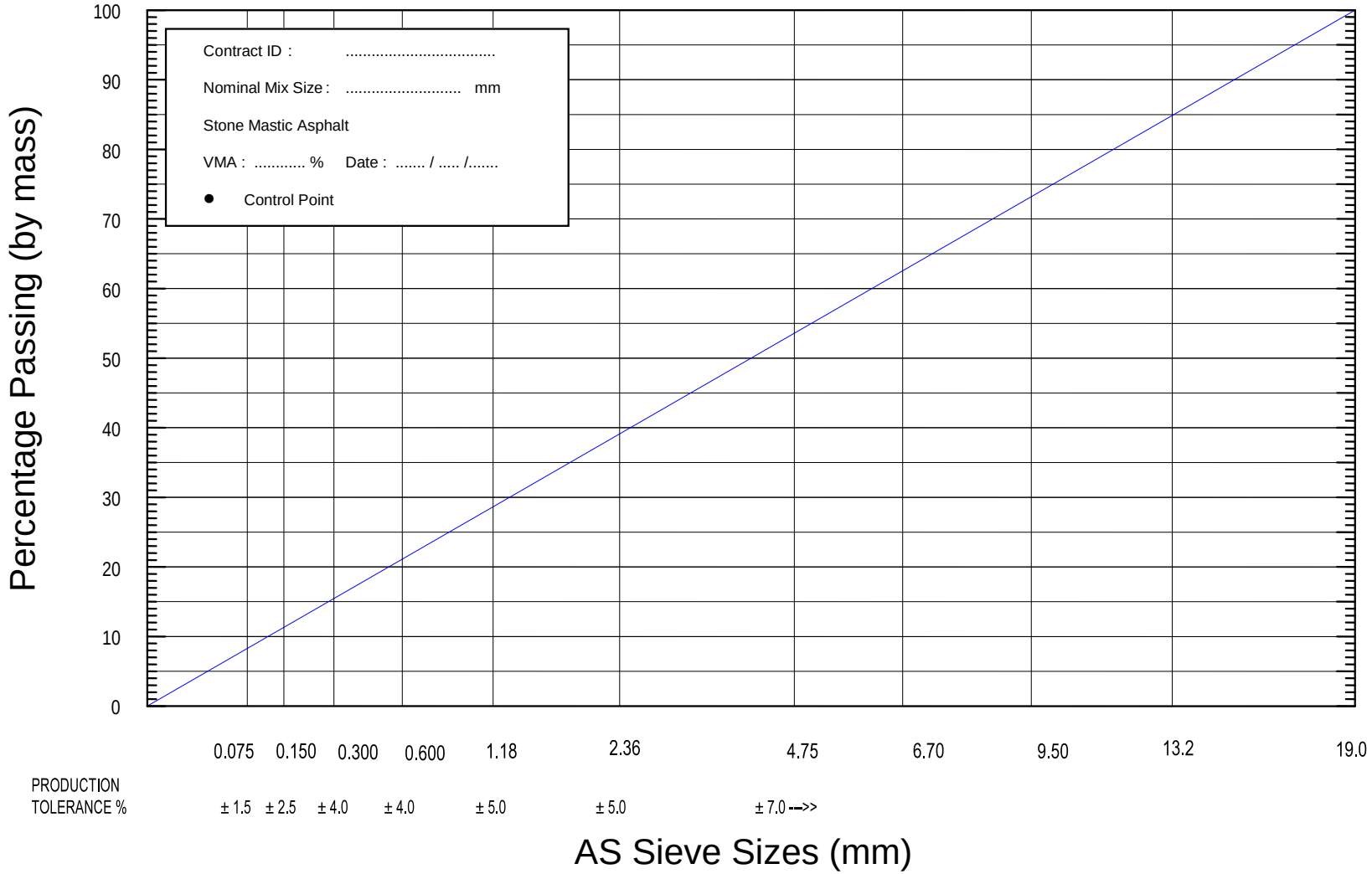

Figure R121.2 - Combined Particle Size Distribution - SMA Nominal Mix size up to 14 mm

R121_F2.PRS

ANNEXURES R121/F TO R121/K – (NOT USED)

ANNEXURE R121/L – MINIMUM FREQUENCY OF TESTING

Attention is drawn to the requirements of Clause 7.5.3 of RMS Q in respect of limits on Lot size.

L1 AGGREGATES

CLAUSE 2.1.1 - COARSE AGGREGATES						
Total Mass of Material represented, (tonnes)		**1 – 500**	**501 – 1,000**	**1,001 – 2,000**	**2,001 – 4,000**	**Refer to Note**
Test Method	**Characteristic Analysed**	**Minimum Frequency of Testing**				
AS 1141.11	Grading	1	1	2	3	
AS 1141.12	Material finer than 75 μm by washing	1	1	2	3	
AS 1141.14	Particle Shape	1	1	2	3	(a)
RMS T239	Fractured Faces	1	2	3	4	
AS 1141.22	Wet Strength	1	1	2	3	(b)
AS 1141.22	Wet/Dry Variation	1	1	2	3	(b)
AS 1141.32	Weak particles	1	1	2	3	
AS 1141.50	Stripping Resistance	1 per 6 months and at change in quarry face				
AS 1141.41, AS 1141.42	PAFV	1 per 6 months and at change in quarry face				
AS 1141.6.1	Water Absorption	1 per 6 months and at change in quarry face				

Notes:

(a) A change in production parameters will initiate the commencement of a new Lot.

(b) Provided that for the six previous Lots actually tested, all tests have met specification requirements for both wet strength and wet/dry strength variation, then apply the following reduced frequency;

where all wet/dry variation results are < 25%: 1 per 10,000 tonnes

where all wet/dry variation results are < 30%: 1 per 4,000 tonnes

where all wet/dry variation results are < 35%: 1 per 2,000 tonnes

CLAUSES 2.1.2 - FINE AGGREGATES						
Total Mass of Material represented, (tonnes)		**1 - 500**	**501 – 1,000**	**1,001 – 2,000**	**2,001 – 4,000**	**Refer to Note**
Test Method	**Characteristic Analysed**	**Minimum Frequency of Testing**				
AS 1141.11	Grading	1	1	2	3	
AS 1141.12	Material finer than 75 μm by washing	1	1	2	3	
	Angularity	1	1	2	3	
AS 1141.5	Water Absorption	1 per 6 months and at change in quarry face				
AS 1141.24	Soundness	1 per 6 months and at change in quarry face				
ISSA Bulletin 145	Methylene Blue Value	1 per 6 months and at change in quarry face				

L2 FILLER

Clause	Characteristic Analysed	Test Method	Minimum Frequency of Testing
2.1.3	Methylene Blue Value	ISSA Technical Bulletin No. 145	One per 10,000 tonnes or part thereof of asphalt production and at change in source of mineral matter
	Fineness (Flyash)	AS 3583 Part 1	One per 500 tonnes of flyash production
	Water soluble fraction (Flyash)	AS 1141.8	One per 500 tonnes of flyash production
	Loss of ignition (Flyash)	AS 3583 Part 3	One per 500 tonnes of flyash production
	Available Lime (Hydrated Lime)	AS 4489.6.1	One per 500 tonnes of hydrated lime production
	Sieve Residue (Hydrated Lime)	AS 4489.2.1	One per 500 tonnes of hydrated lime production

L3 PRODUCTION SMA

Clause	Characteristic Analysed	Test Method	Minimum Frequency of Testing
2.2.1	Binder Content	AS 2891.3.1	As set out in Clause 2.3.2, Table R121.2
2.2.2	Particle Size Distribution of combined aggregate	AS 2891.3.1	As set out in Clause 2.3.2, Table R121.2
2.2.3	VMA and voids in laboratory compacted SMA at 80 or 120 cycles of compaction	AS 2891.2.2, AS 2891.7.3, AS 2891.8 & AS 2891.9.2	As set out in Clause 2.3.2, Table R121.2
2.2.3	Voids in laboratory compacted SMA at 350 cycles of compaction	AS 2891.2.2, AS 2891.7.3, AS 2891.8 & AS 2891.9.2	One per production Lot
2.2.3	Dry compacted voids in mineral matter passing 0.075 mm AS sieve	AS 1141.11 & As 1141.17	One per 10,000 tonnes or part thereof of asphalt production and at change in source of mineral matter

L4 PLACING SMA

Clause	Characteristic Analysed	Test Method	Minimum Frequency of Testing
4.5	Temperature of existing pavement	Contractor's Written Procedure	One every two hours
4.6	Asphalt temperature at time of placing	Refer to Clause 4.6	One per delivered load
4.7	Tack coat application rate	Contractor's Written Procedure	One per lot
4.2	Temperature of compacted SMA	Contractor's Written Procedure	One prior to opening to traffic

L5 INSITU SMA

Clause	Characteristic Analysed	Test Method	Minimum Frequency of Testing
5.1	Compacted course thickness	Refer to Clause 5.1	One per Lot
5.2	Shape	Contractor's Written Procedure	
5.3	Ride quality	RMS T182 or RMS T187	One per ride quality Lot [#]

Note [#]: Riding quality lot must be in accordance with Clause 5.3.

ANNEXURE R121/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.4.

RMS Specifications

RMS G10	Traffic Management
RMS Q	Quality Management System
RMS 3211	Cements, Binders and Fillers
RMS 3252	Polymer Modified Binder
RMS 3253	Bitumen for Pavements
RMS 3259	Bitumen Adhesion Agent (for Bitumen)
RMS 3269	Bitumen Adhesion Agent (for Polymer modified bitumen)

RMS Test Methods

RMS T182	Road Roughness Testing
RMS T187	Measurement of Ride Quality of Road Pavements by Laser Profiler
RMS T230	Resistance to Stripping of Aggregates and Binders
RMS T239	Fractured Faces of Coarse Aggregate

Australian Standards

AS 1160	Bituminous emulsions for construction and maintenance of pavements
AS 2008	Residual bitumen for pavements
AS 2150	Asphalt (Hot-Mixed)
AS 2357	Mineral Fillers for Asphalt
AS 2734	Asphalt (Hot-Mixed) Paving - Guide to Good Practice
AS 2758.5	Asphalt Aggregates
AS 3582.1	Fly ash

Australian Standard Test Methods

AS 1141.5	Particle Density and Water Absorption of Fine Aggregate
AS 1141.6.1	Particle Density and Water Absorption of Coarse Aggregate
AS 1141.8	Water-soluble fraction of filler
AS 1141.11	Particle size distribution by dry sieving
AS 1141.12	Material finer than 75 μm in aggregates (by washing)
AS 1141.14	Particle shape by proportional calliper
AS 1141.17	Voids in dry compacted filler
AS 1141.18	Crushed particles in coarse aggregate derived from gravel

AS 1141.22	Wet/dry strength variation
AS 1141.24	Aggregate soundness by exposure to sodium sulphate solution
AS 1141.32	Weak particles in coarse aggregates
AS 1141.41	Laboratory polishing of aggregate using horizontal bed machine
AS 1141.42	Pendulum friction test
AS 1141.50	Resistance to stripping
AS 2891.1	Sampling of asphalt
AS 2891.2.2	Compaction of asphalt test specimens using a gyratory compactor.
AS 2891.3.1	Bitumen content and aggregate grading - Reflux method
AS 2891.7.3	Maximum density of asphalt - Methylated spirit displacement
AS 2891.8	Voids and density relationships of compacted asphalt mixes
AS 2891.9.2	Determination of bulk density of compacted asphalt - Presaturation method
AS 3583.1	Determination of fineness by the 45 micrometer sieve
AS 3583.3	Determination of loss on ignition
AS 4489.2.1	Test methods for limes and limestones – Fineness – Wet sieving
AS 4489.6.1	Test methods for limes and limestones – Lime index – Available lime

Austroads Documents

APRG 18	Selection and design of asphalt mixes

International Slurry Surfacing Association Documents

Bulletin 145	Determination of Methylene Blue Adsorption Value

AASHTO Test Methods

T 304-96	Uncompacted Void Content of Fine Aggregate