AUSTRALIAN ASPHALT PAVEMENT ASSOCIATION

Australian Asphalt Pavement Association

Crumb Rubber Modified Open Graded and Gap Graded Asphalt Pilot Specification

---

Version: 1.0
12 June 2018

Published by
National Technology and Leadership Committee

Preface

This pilot specification is intended as a guide for asset owners in the creation of technical specifications for the supply of crumb rubber modified (CRM) open graded asphalt (OGA) and gap graded asphalt (GGA) mixes. The mixes contain a bituminous binder with partially digested crumb rubber (i.e. high-viscosity CRM binder).

The crumb rubber modified binder technology in this specification is based on the technology used in California and Arizona.

The CRM OGA mix design process in this specification has been validated through demonstration trials in Australia.

The **CRM GGA mix design process described in this specification is yet to be validated in Australia**.

The aim of this pilot specification is to facilitate the construction of demonstration trials of CRM GGA, as well as to promote the wider use of CRM OGA in Australia.

The content of this specification builds on information in the following documents

- *Transport and Main Roads Specification PSTS112 Crumb Rubber Modified Open Graded Asphalt Surfacing,* Queensland Government, 2016 (not published).
- *National Asphalt Specification*, 2nd edition, Australian Asphalt Pavement Association, Melbourne, VIC, 2004.
- State of California Department of Transport (Caltrans) Standard Specifications – Division V – Section 39, Caltrans, 2015.
- Arizona Department of Transportation (ADOT) Standard Specifications for Road and Bridge Construction, ADOT, 2008.
- *AS 2150-2005 Hot mix asphalt a guide to good practice*, Standards Australia

Acknowledgements

The development of this pilot specification is a result of a collaborative effort between representatives from state road agencies, the Australian Road Research Board, Tyre Stewardship Australia and industry. The AAPA National Technology and Leadership Committee especially acknowledges the contributions of the Queensland Department of Transport and Main Roads, Main Roads Western Australia, the Australian Research Board and the Queensland AAPA Technical Committee.

1. General

1.1. Scope

This pilot specification sets out the requirements for crumb rubber modified (CRM) open graded asphalt (OGA) surface layers with a nominal maximum aggregate size of 10 mm and 14 mm. The specification also includes requirements for CRM gap graded asphalt (GGA) mixes with a nominal maximum aggregate size of 14 mm and 20 mm. The specification covers:

- Constituent materials
- OGA and GGA mix design requirements
- Process control in manufacture and placement of asphalt
- Acceptance criteria for the finished CRM asphalt pavement
- Quality systems, minimum process standards, plant requirements and sampling and testing frequencies.

1.2. Quality system requirements

The Contractor shall establish, implement and maintain a Quality System in accordance with this Specification and the requirements of AS/NZS ISO 9001, or an equivalent system approved by the Principal. The Quality System shall include the appropriate Occupational Health and Safety procedures and Safe Working Method Statements.

Where required in the Contract general clauses, the Contractor shall submit a Quality Plan prior to commencement of any works. The Quality Plan shall take into account the specific requirements for inspection and testing, acceptance/rejection criteria, details of proposed methods and other quality requirements that are contained in the Contract Documents. No part of the Quality System shall be used to pre-empt or otherwise negate the technical requirements of the Contract Documents.

1.3. Testing requirements

All testing of properties required by this Specification shall be undertaken in a laboratory accredited by the National Association of Testing Authorities (NATA) or International Accreditation New Zealand (IANZ) for the appropriate tests and performed in accordance with procedures contained in the relevant Australian Standard or Austroads Manual of Test Procedures. Where there is no applicable Australian Standard or Austroads Test Method, or where the Standard/Manual provides a choice of procedures, the method to be adopted shall be agreed between the Principal and the Contractor.

1.4. Defect liability period

During the first 12 months, the product must not rut, shove, strip, ravel or bleed.

2. Constituent materials

2.1. Aggregate & mineral filler

2.1.1. General

All aggregates shall be obtained from established quarries and have established properties. Each individual aggregate fraction shall be obtained from the same quarry as the materials used in the design of the Job Mix.

An appropriate system of stockpile management shall be implemented at the quarry and asphalt plant to ensure contamination does not occur.

All mineral filler shall come from established sources and have established properties.

2.1.2. Coarse aggregate

Coarse aggregate is comprised of crushed rock particles that are substantially retained on the 4.75 mm sieve. Coarse aggregate shall comply with Australian Standard AS 2758.5 with the application of those test properties specified in Table 2-1 as appropriate.

Table 2-1: Coarse aggregate requirements

Property	Test Method	Requirement
Particle size distribution (PSD)	AS 1141.11.1	Report
Crushed particles (1)	AS 1141.18	100% crushed aggregate
Polished aggregate friction value (PAFV)	AS 1141.40, or AS 1141.41	≥ 48 (2)
Particle density (Dry basis)	AS 1141.6.1, or AS1141.6.2	report
Water absorption	AS 1141.6.1, or AS1141.6.2	≤ 2.5 %
Los Angeles abrasion loss (3)	AS 1141.23	≤ 25 %
Ten percent fines value (wet) (3)	AS 1141.22	≥ 150 kN
Wet/dry strength variation (3)	AS 1141.22	≤ 35 %
Flakiness index	AS 1141.15	≤ 25%

Notes:

1. Test only required on river gravels and metasediments
2. In some regions aggregates that comply with the PAFV requirements in Table 2-1 may not be available. Where this is the case, a lower PAFV requirement may be proposed for acceptance by the Principal.
3. Aggregate to be tested for either Los Angeles abrasion loss, or wet strength and wet/dry strength variation

2.1.3. Fine aggregate

Fine aggregate shall consist of crushed rock particles substantially passing the 4.75 mm sieve and manufactured from an approved source complying with the requirements of Section 2.1.2.

The fine aggregate shall be clean, hard, durable and free from lumps of clay and other aggregations of fine materials, organic material and any other deleterious material. Fine aggregate shall comply with the criteria in Table 2-2.

Table 2-2: Fine aggregate requirements

Property	Test Method	Requirement
Particle size distribution (PSD)	AS 1141.11.1	Report
Particle density (Dry basis)	AS 1141.5	Report
Water absorption	AS 1141.5	≤ 2.5 %
Degradation Factor, Crusher fines (1)	AS 1141.25.3	≥ 60
Sodium Sulfate Soundness (weighted loss) (1)	AS 1141.24	≤ 12%

Notes:

1. Aggregate to be tested for either degradation factor, or Sodium Sulfate Soundness

2.1.4. Mineral filler

Mineral filler is that portion of mineral matter passing a 0.075 mm sieve, and includes rock dust derived from coarse and fine aggregates used in the production of asphalt in accordance with this specification, and any other materials added to supplement the quantity and properties of filler in the mix.

OGA shall contain hydrated lime, or adhesion agent. Where hydrated lime is used a minimum of 1.0% shall apply.

The combined filler shall comply with the requirements in Table 2-3

Table 2-3: Combined filler requirements

Property	Test Method	Requirement
Voids in dry compacted filler	AS/NZS 1141.17	≥ 28 % and ≤ 45 %
Apparent density of filler	AS/NZS 1141.7	Report
Methylene blue test[1]	AS 1141.66	≤ 18[2] ≤ 10[3]

Notes:

This requirement shall only apply for aggregate from New South Wales or Queensland.

This requirement shall apply on the combined filler in asphalt (excluding hydrated lime)

3. Where methylene blue value of the combined filler (excluding hydrated lime) exceeds 10 mg/g, the methylene blue value of combined filler (including hydrated lime) shall not exceed this value.

Added filler (material not derived from the aggregate components) shall comply with the relevant standards listed in Table 2-4. Rock dust that is not derived from the other aggregate components in the mixture may also be used as added filler provided that it is derived from materials that meet the requirements of Clause 2.1.2

Table 2-4: Standards for materials used as filler

Material	Standard[1]
Hydrated lime	AS 1672.1
Fly Ash	AS/NZS 3582.1
Cement Kiln Dust	See note 2
Slag	AS/NZS 3582.2
Ground Limestone	See note 3

Notes:

1. Provision of test certificates for compliance with the relevant Australian Standard and this specification shall be limited to those tests listed in Table 2-4.
2. Cement kiln dust shall be solid material extracted from the flue gases in the manufacture of Portland cement, having a maximum water-soluble fraction of 20% by mass and complying with the grading limits specified in Table 2-5
3. Ground limestone shall consist of rock dust derived from the grinding of limestone.

The particle distribution of all added filler fractions shall comply with the grading limits specified in Table 2-5.

Table 2-5: Grading limits for added filler

Test method	Sieve size (mm)	Percentage passing sieve size (by mass)
AS 1141.11.1	0.600	100
	0.300	95–100
	0.075	75–100

Each type of added filler from each source shall be mineral material, dry and free from lumps, organic material or other deleterious matter, and conform to AS 2150. The added filler shall comply with the requirements in Table 2-6.

Table 2-6 Requirements for added filler

Property	Test Method	Requirement
Moisture content	AS 4489.6.1	≤ 3 %
Apparent density	AS/NZS 1141.7	Report

2.1.5. Tyre derived Crumb Rubber

The rubber crumb must be produced from end-of-life tyres. The use of uncured or devulcanized rubber is not permitted. The crumb rubber must be dry, free-flowing particles that do not stick together. The crumb rubber must not cause foaming when combined with the bituminous binder. The crumb rubber shall be an essentially uniform material and meet the requirements of Table 2-7.

Table 2-7 Requirements for rubber crumb

Property	Test Method	Requirement
Grading	AGPT/T143	
passing 2.36 mm		100
passing 1.18 mm		#
passing 600 μm		#
passing 300 μm		#
passing 150 μm		#
passing 75 μm		#
Particle length (mm) max.	AGPT/T143	3
Bulk density (kg/m^3)	AGPT/T144	Report
Water content (%) max.	AGPT/T143	1
Foreign materials – other than iron (%) max.	AGPT/T143	0.1
Foreign materials – metallic iron (%) max.	AGPT/T143	0.1

target grading and production tolerances to be nominated by the Contractor as part of the asphalt mix design submission.

A certificate of compliance shall be provided by the Contractor confirming that all of the crumb rubber requirements have been met.

2.2. Extender oils

Extender oils, if used, shall be added to the bitumen prior to the addition of the crumb rubber. Extender oils shall be a resinous, high flash point, aromatic hydrocarbon.

2.3. Binder

2.3.1. Binder design

The base binder shall be a bitumen complying with the requirements in AS 2008. The class of source of bitumen to be used for the binder shall be nominated by the Contractor. The crumb rubber modified binder shall contain between 18% and 22% of crumb rubber by mass of total binder.

The contract shall submit a binder design profile with the asphalt mix design based on the testing requirements in Table 2-8.

Table 2-8 CRM binder design profile to be submitted with mix design

Property	Test method	Reaction time (from incorporation of rubber into the binder)				
		60 mins	120 mins	240 mins	360 mins	TBN[2]
Penetration @ 4ºC, 200 g, 60 sec, 0.10 mm, minimum	AS 2341.12	15	-	15	-	15
Penetration @ 25ºC, 100 g, 5 sec, 0.10 mm, minimum	AS 2341.12	TBR[1]		TBR[1]		TBR[1]
Resilience @ 25°C, percent rebound, minimum	ASTM D5329	20	-	20	-	20
Torsional recovery at 25ºC 30 s, %	AG:PT/T122	TBR[1]	-	TBR[1]	-	TBR[1]
Softening point, °C, minimum	AG:PT/ T131	55	-	55	-	55
Viscosity at 175°C, Pa.s	AG:PT/T111	1.5–4.0	1.5–4.0	1.5–4.0	1.5–4.0	1.5–4.0

Notes:

1. TBR denotes to be reported.
2. TBN denotes to be nominated by the Contractor. Where the contractor desires to store the crumb rubber modified binder in excess of 10 hours (after the initial 60 minutes reaction period) but not more that 4 days (96 hours after the 60 minute reaction period) prior to usage, testing should be completed to confirm compliance with the specification requirements.

2.3.2. Binder production testing

The binder for crumb rubber modified open graded and gap graded asphalt shall comply with the requirements in Table 2-9 after a minimum reaction time of 60 minutes. This testing shall apply to the first batch of binder supplied for each project. Subsequent batches be tested for compliance with softening point, resilience and viscosity at 175°C only.

Table 2-9 Requirements for crumb rubber modified binder after min. 60 mins reaction time

Property	Test method	Requirement
Penetration @ 4ºC, 200 g, 60 sec, 0.10 mm, minimum	AS 2341.12	15
Penetration @ 25ºC, 100 g, 5 sec, 0.10 mm, minimum	AS 2341.12	TBR[1]
Resilience @ 25°C, percent rebound, minimum	ASTM D5329	20
Torsional recovery at 25ºC 30 s, %	AG:PT/T122	TBR[1]
Softening point, °C, minimum	AG:PT/ T131	55
Viscosity at 175°C, Pa.s	AG:PT/T111, or ASTM D7741/ D7741M[2, 3]	1.5-4.0
Flash Point, °C, minimum	AG:PT/T112	250
Loss on Heating, %, maximum	AG:PT/T103	0.6

1. TBR denotes to be reported.
2. The viscometer used shall be a Rion (formerly Haake) Model VT-04 viscometer using the No. 1 Rotor. The Rion viscometer rotor, while in the off position, shall be completely immersed in the binder at a temperature from 175 to 180ºC for a minimum heat equilibrium period of 60 seconds, and the average

viscosity determined from three separate constant readings (± 0.5 Pa.s). taken within a 30 second time frame with the viscometer level during testing and turned off between readings.

3. The accuracy of the viscometer shall be verified by comparing the viscosity results obtained with the Brookfield viscometer to 3 separate calibration fluids of known viscosities ranging from 1.0 to 5.0 Pa.s. The viscometer will be considered accurate if the values obtained are within 0.3 Pa.s of the known viscosity. The known viscosity value shall be based on the fluid manufacturers standard test temperature or the test temperature versus viscosity correlation table provided by the fluid manufacturer. Viscometers used on the project shall be verified to be accurate. The accuracy verification results shall be provided to the Principal.

2.3.3. Binder testing at time of asphalt production

At the time of asphalt production, the binder shall comply with the requirements in Table 2-11. Binder compliance shall be assessed on samples taken from the feed line connecting the CRM binder tank to the asphalt plant at the time of use in asphalt production.

Table 2-10 Requirements for crumb rubber modified binder at time of asphalt production

Property	Test method	Requirement
Viscosity at 175°C, Pa.s	AG:PT/T111, or ASTM D7741/ D7741M[1, 2]	1.5-4.0

1. The viscometer used shall be a Rion (formerly Haake) Model VT-04 viscometer using the No. 1 Rotor. The Rion viscometer rotor, while in the off position, shall be completely immersed in the binder at a temperature from 175 to 180ºC for a minimum heat equilibrium period of 60 seconds, and the average viscosity determined from three separate constant readings (± 0.5 Pa.s). taken within a 30 second time frame with the viscometer level during testing and turned off between readings.
2. The accuracy of the viscometer shall be verified by comparing the viscosity results obtained with the Brookfield viscometer to 3 separate calibration fluids of known viscosities ranging from 1.0 to 5.0 Pa.s. The viscometer will be considered accurate if the values obtained are within 0.3 Pa.s of the known viscosity. The known viscosity value shall be based on the fluid manufacturers standard test temperature or the test temperature versus viscosity correlation table provided by the fluid manufacturer. Viscometers used on the project shall be verified to be accurate. The accuracy verification results shall be provided to the Principal.

2.4. Reclaimed asphalt pavement

Reclaimed asphalt pavement (RAP) shall not be used in OGA or GGA.

2.5. Additives

2.5.1. Cellulose fibres

Cellulose fibres may be included in the OGA mix design to ensure compliance with binder drain-off in Table 3.2.

2.5.2. Adhesion agent

Adhesion agent may be added up to 1.0% by mass of bitumen to improve the moisture sensitivity properties of the GGA mix design, where required. The type and proportion of the adhesion agent shall be in accordance with a manufacturer's recommendation, purchaser's specification or as agreed between the Principal and Contractor.

2.5.3. Warm mix asphalt additive

Warm mix asphalt additive must be included in the asphalt mix design to reduce the manufacturing and placement temperature. The type and proportion of the warm mix additive

shall be in accordance with a manufacturer's recommendation, purchaser's specification or as agreed between the Principal and the Contractor.

3. Mix design

3.1. General

The Contractor shall provide a mix design that complies with the requirements of this specification. Where the proposed mix design incorporates additives listed under Clause 2.1, compliance shall be tested on the mix including these additives. Where specified, the Contractor's mix design shall be submitted for approval, or registration.

3.2. Aggregate grading

The target combined aggregate grading (including filler) determined in accordance with AS/NZS2891.3.1, AS/NZS2891.3.2, AS/NZS2891.3.3, or AGPT/T234 shall comply with the limits given in Table 3-1.

Table 3-1: GGA and OGA aggregate grading limits

Sieve Size AS (mm)	Mix designation			
	GGA14	GGA20	OGA10	OGA14
	Percentage passing sieve size (by mass)			
26.5		100		
19.0	100	95-98		100
13.2	90-98	83-87	100	85–100
9.5	83-87	65-70	85–100	45–70
6.7	#	#	35–70	25–45
4.75	28–42	28-42	20–45	10–25
2.36	14–22	14-22	10–20	7–15
1.18	#	#	6–14	6–12
0.600	#	#	5–10	5–10
0.300	#	#	4–8	4–8
0.150	#	#	3–7	3–7
0.075	0–6	0-6	2–5	2–5

Notes:

In some regions aggregates that meet the grading envelope requirements in Table 3-1 may not be available. Where this is the case, adjustments to the requirements may be proposed for acceptance by the Principal.
Target value to be nominated by the Contractor

3.3. Binder content

OGA shall contain a minimum of 6.0 percent CRM binder by mass of total mix.

GGA shall contain a minimum of 7.5 percent CRM binder by mass of total mix.

Note: the specified binder content range is applicable to commonly used natural aggregates and sands. Where the Contractor proposes to use constituents of substantially different density, the Contractor may propose a nonconforming binder content subject to the approval of the Principal. The Contractor must demonstrate that the effective volumetric binder content complies with the intent of the Specification.

3.4. Cellulose fibres

If cellulose fibres are required to meet drain-off requirements for OGA, the minimum application rate shall be 0.15 % by mass of total mix.

3.5. Mix properties

The volumetric design of OGA shall be performed with Marshall laboratory compaction equipment as described below. The asphalt mix for the design shall be prepared in accordance with AS/NZS 2891.2.1. Test specimens compacted in accordance with AS/NZS 2891.5 using 50 blows per face Marshall compaction effort and the resultant test specimens shall comply with the requirements in Table 3-3. The temperature for compaction of Marshall specimens shall be determined in accordance with Appendix B of AS 2891.5.

Table 3-2: OGA mix requirements (Marshall design method)

Property	Test Method	Requirement
Combined mineral aggregate density (t/m^3)	AS/NZS 2891.8	Report
Binder film index	AS/NZS 2891.8	≥ 18
Air voids content (%)	AS/NZS 2891.8	≥ 20
Particle loss (%)	AGPT/T236	≤ 20
Asphalt binder drain off	AGPT/T235	≤ 0.3

The volumetric design of GGA shall be performed using gyratory compaction and be in accordance with the Superpave Mix Design: Superpave Series No. 2 manual published by the Asphalt Institute and comply with the requirements in Table 3-3.

Table 3-3: GGA mix requirements (Superpave design method)

Property	Test Method	Requirement
Air voids content (%)	AS/NZS 2891.9.2	Ndesign = 4.0
Gyratory compaction (no. of gyrations)	AS/NZS 2891.2.2[1,5]	N = 50-150
Voids in mineral aggregate (%)	AS/NZS 2891.8	18 - 23
Filler/binder ratio	n/a	Report
Permanent deformation (min, number of passes at 12 mm rut depth)	TMR Q325[4]	20,000[2]
Moisture damage (min, number of passes at the inflection point)	TMR Q325[4]	10,000[2]
Moisture sensitivity TSR (%)	AGPT-T232[3]	≥ 80[2]
Determine number of Marshall blows to 4% air voids, or, Determine number of gyrations to 4% air voids	AS/NZS 2891.5 or AS/NZS 2891.2.2, AS/NZS 2891.9.26, AS/NZS 2891.7.3 and AS 2891.8	Report[2]

Notes:

1. Gyratory compactor pressure must be increased to a maximum of 825 kPa and specimens may be held at a constant height for a maximum of 90 minutes. An internal gyratory angle of 1.16 degrees and 30 ± 0.5 rev/minute must be used.
2. Testing shall be undertaken on plant produced asphalt samples.
3. Freeze-thaw cycle required.
4. The following test conditions shall apply:

- Target air voids shall equal 7.0±1%
- Test temperature shall be 50 °C ± 1 °C
- Specimen height shall be 60 ± 1 mm
- The minimum number of test specimens shall be 4 to allow for 2 tests (averaging of the 2 test results will not be allowed)
- Measurements shall be taken at every 100 passes along the total specimen length)
- The inflection point is defined as the number of wheel passes at the intersection between the creep slope and stripping slope
- Condition the specimens in water at the test temperature for 2 and 4 hours prior to testing
- The test shall be terminated at 25,000 passes.

5. The compaction temperature shall be between 145 °C – 160 °C.

The optimum binder content shall be determined as follow:

1. The optimum binder content calculations shall be based on the average of 3 briquettes prepared at each CRM binder content. At least four different binder contents shall be tested, with the minimum content being 7.5%.
2. Confirm that the specimens meet the minimum binder content and voids in mineral aggregate requirements at 50 and 150 gyrations and discard mixes that do not meet these requirements.
3. Plot the CRM binder content against the average air voids content and draw a best-fit curve through the data points.
4. Determine the VMA for each briquette and plot the average of each set against the CRM binder content.
5. Determine the filler/binder ratio and plot this value against the CRM binder content.
6. Select an optimum binder content at 4% air voids from the air voids content curve.
7. Confirm the filler/binder ratio and VMA at the optimum binder content.

3.6. Mix design report

The mix design report shall include the following information:

1. Details of manufacturer and manufacturing plant where the mix will be produced.
2. Design grading and binder content.
3. Details of all constituent materials and their proportions, as well as test results from a NATA accredited laboratory demonstrating that the constituents comply with the requirements in Clause 2.
4. Test results provided by a NATA accredited laboratory demonstrating that the mix design complies with the requirements in Clause 3.5.
5. A signed declaration that the mix design complies with the requirements of this specification.
6. Reference to this specification.

4. Manufacture and storage

4.1. General

Asphalt manufacturing plant shall be capable of consistently producing asphalt mixes with the properties specified and at a rate suitable for smooth, continuous asphalt placing.

4.2. Binder production

The temperature of the crumb rubber modified binder immediately after the initial dispersion of the crumb rubber into the bitumen shall be between 165 and 200°C. The producer shall ensure that the crumb rubber and bitumen are thoroughly mixed prior to the beginning of the reaction period. The reaction period shall be a minimum of 60 minutes, during which time the crumb rubber modified binder is continued to be mixed while the temperature between 165 and 200°C. The producer shall ensure the crumb rubber particles have been uniformly incorporated into the mixture and that they have been “wetted”. The occurrence of the crumb rubber floating on the surface or agglomerations of crumb rubber particles is evidence of insufficient mixing.

4.3. Storage of aggregate and filler

Raw materials shall be stored at the mixing site in sufficient quantities to ensure continuity of production and enable effective sampling and testing prior to use. The facilities for handling particular materials shall comply with the following:

a. Aggregates shall be handled and stored in such a manner as to prevent contamination and avoid segregation.
b. Filler shall be handled and stored in such a manner as to keep it dry and free flowing at all times. Where more than one type of filler is to be used, each shall be handled and stored separately.
c. Additives shall be protected from moisture or contamination.

4.4. Binder storage

a. Tanks for heating and storage of bitumen shall be thermostatically controlled and each shall be fitted with a thermometer that is located so that the temperature can be read conveniently.
b. An appropriate bitumen sampling point shall be provided.

Once the crumb rubber modified binder has been mixed, it shall be kept thoroughly agitated to prevent settling of the crumb rubber particles. The temperature of the crumb rubber modified binder shall be maintained between 165 ºC and 190 ºC.

If in the first ten hours after the completion of the reaction period the temperature of the crumb rubber modified binder drops below 165 ºC, it may be reheated to a temperature between 165 and 190 ºC.

In no case shall the crumb rubber modified binder be held at a temperature between 165 ºC to 190 ºC for more than ten hours after the completion of the reaction period. Crumb rubber modified binder that is to be held for more than ten hours shall be allowed to cool and gradually reheated to a temperature between 165 ºC and 190 ºC before use.

The reheating of crumb rubber modified binder that has cooled below 165 ºC shall not be allowed more than once, unless otherwise approved by the Administrator.

Crumb rubber modified binder shall not be held at temperature above 120 ºC for more than four days after the completion of the reaction period unless otherwise approved by the Administrator.

For each load or batch of crumb rubber modified binder, the Contractor shall provide to the Administrator with the following documentation:

- The temperature of the bitumen prior to the addition of crumb rubber
- The source, grade, amount and temperature of the bitumen prior to the addition of crumb rubber
- The crumb rubber content expressed as percent by the weight of total binder
- Times and dates of the crumb rubber additions and resultant binder viscosity.
- A record of the temperature, with time and date reference for each load or batch. The record shall begin at the time of the addition of crumb rubber and continue until the load or batch is completely used. Readings and recordings shall be made at every temperature change in excess of 10 ºC, and as needed to document other events which are significant to batch use and quality.

Immediately prior to use, the viscosity of the crumb rubber modified binder shall be tested by the Contractor with a rotational viscometer (ASTM D7741/D7741M or AG:PT/T111). The binder shall meet the viscosity requirements of Table 2-11.

4.5. Mixing temperatures

The temperature of the modified binder delivered into the mixer shall not exceed 190 ºC. The exit temperature of the material from the mixer shall not exceed 165 ºC.

4.6. Addition of filler

Filler systems shall be designed or modified to provide for the appropriate quantity of added filler. In drum mix plants, loss of filler shall be minimised by feeding direct into the mixer alongside addition of binder.

4.7. Addition of fibres

The following requirements shall apply to the process of adding cellulose fibres:

a. Fibre shall be added in a manner that ensures good dispersion of fibres, avoids loss of fibre through dust collection systems and avoids damage to fibre by overheating.
b. Mixing times shall be increased, where necessary, to ensure adequate dispersal and mixing of fibre.

4.8. Particle coating

The degree of particle coating shall be not less than 99%, when determined in accordance with AS/NZS 2891.11, once discharged from the asphalt plant into delivery vehicles.

4.9. Production tolerances

The proportion of the different aggregate fractions may be varied for the purpose of process control provided that the asphalt produced remains essentially uniform and consistent and in compliance with the nominated mix submission. The actual particle size distribution and binder content of the production mix may vary from the values nominated in the mix design report within the limits shown in Table 4-1.

Table 4-1: Production tolerances

Description	Test method	Tolerance
Permissible variation to nominated combined particle size distribution during production (% by mass of total aggregate)	AS/NZS 2891.3.1, or AG:PT/T234[1]	
Passing 4.75 mm sieve and larger		± 7
Passing 2.36 mm and 1.18 mm sieves		± 5
Passing 0.600 mm and 0.300 mm sieves		± 4
Passing 0.150 mm sieve		± 2.5
Passing 0.075 mm sieve		± 1.5
Permissible variation to the nominated binder content during production (% by mass of total mix)	AS/NZS 2891.3.1[2], or AG:PT/T234[3]	± 0.5
Permissible variation to the nominated maximum density during production (t/m^3)	AS/NZS 2891.7.1	± 0.035
Permissible variation to the nominated air voids content during production[4] (%)	AS 2891.8	± 1.5
Moisture content (%)	AS/NZS 2891.10.	0.5

Notes:

1. The particle size distribution shall be adjusted using the 'wet' method in Appendix A of AG:PT/T234.
2. When using test method AS/NZS 2891.3.1, the binder content shall be adjusted using the procedure described in Section 5 of Manual 19 – May 2016 Guidelines for the design, manufacture and construction of bitumen-rubber asphalt wearing courses published by the South African Bitumen Association (www.sabita.co.za).
3. The binder content determined shall be adjusted using the 'wet' method in Appendix A of AG:PT/T234.
4. At number of blows Marshall 4.0 design air voids determined as per Table 3.3, or number of gyrations to 4.0% air voids as per Table 3.3.

4.10. Storage of mixed asphalt

Asphalt may be stored prior to delivery to the purchaser, subject to the following requirements being observed:

a. The mix is consigned to and deposited in the storage bins in such a manner as to minimise segregation.
b. The storage bin shall be insulated.
c. The method of discharge shall be such as to minimise segregation. Any caked or segregated portions of mix shall be discarded.

5. Sampling and testing during production

5.1. General

The Contractor shall arrange for all relevant testing.

Samples from asphalt production shall be taken at the required frequency in Table 5-1 in accordance with AS/NZS 2891.1.1. Samples shall not be mixed. In addition, each loaded truck shall be visually inspected for segregation, uncoated particles, excess bitumen or overheating, before dispatch from the plant.

5.2. Frequency of sampling and testing

Frequency of sampling and testing shall be not less than that shown in Tables 5-1 and 5-2. Table 5-1 provides for two levels of minimum frequency. The reduced frequency may only be adopted where the process is demonstrated to be under statistical control as specified in Section 5.3. Where a non-conformance occurs in any test requirement, the frequency of sampling and testing for that particular property shall be increased to the normal level until conforming results have been obtained on five consecutive samples.

Table 5-1: Frequency of sampling and testing of produced asphalt

Property	Test Method	Normal minimum frequency	Reduced minimum frequency
Binder content and grading	AS/NZS 2891.3.1[1], or AG:PT/T234[2]	One test per 300 t of asphalt production, or part thereof over 30 t.	One test per 500 t of asphalt production, or part thereof over 30 t.
Maximum density	AS/NZS 2891.7.1	One test per 300 t of asphalt production, or part thereof over 30 t.	One test per 500 t of asphalt production, or part thereof over 30 t.
Moisture content	AS/NZS 2891.10	One test per 2,500 t of asphalt production, or 1 test per shift, whichever is greater.	One test per 2,500 t of asphalt production, or 1 test per shift, whichever is greater.
Air voids content (Marshall compacted specimens)[3]	AS/NZS 2891.5, AS/NZS 2891.9.2, AS/NZS 2891.7.3 and AS 2891.8	One test per 300 t of asphalt production, or part thereof over 30 t.	One test per 500 t of asphalt production, or part thereof over 500 t.
Air voids content (Gyratory compacted specimens)[3]	AS/NZS 2891.2.2 AS/NZS 2891.9.2, AS/NZS 2891.7.3 and AS 2891.8	One test per 300 t of asphalt production, or part thereof over 30 t.	One test per 500 t of asphalt production, or part thereof over 500 t.
Voids in mineral aggregate	AS/NZS 2891.8	One test per 300 t of asphalt production, or part thereof over 30 t	One test per 500 t of asphalt production, or part thereof over 500 t
Moisture sensitivity	AGPT-T232[4]	One test per 5,000 t of asphalt production, or 1 test per project, whichever is greater.	One test per 10,000 t of asphalt production, or 1 test per project, whichever is greater.
Temperature of asphalt discharged from plant	Probe digital thermometer	Each loaded truck	Lesser of each loaded truck or one per 15 minutes

Notes:

1. When using test method AS/NZS 2891.3.1, the binder content shall be adjusted using the procedure described in Section 5 of Manual 19 – May 2016 Guidelines for the design, manufacture and construction of bitumen-rubber asphalt wearing courses published by the South African Bitumen Association.
2. The particle size distribution and binder content shall be adjusted using the 'wet' method in Appendix A of AG:PT/T234.
3. Either Marshall compaction or gyratory compaction shall be used.
4. Freeze-thaw cycle required.

Table 5-2: Frequency of testing of constituent materials

Property	Test Method	Normal minimum frequency
Crushed particles[1]	AS 1141.18	3 Monthly
Aggregate density and water absorption	AS 1141.6.1, or AS1141.6.2	3 Monthly
Los Angeles abrasion loss [2]	AS 1141.23	3 Monthly
Ten percent fines value (wet) [2]	AS 1141.22	3 Monthly
Wet/dry strength variation [2]	AS 1141.22	3 Monthly
Flakiness index of coarse aggregate	AS 1141.15	Monthly
Voids in dry compacted filler (combined filler)	AS/NZS 1141.17	Monthly
Binder blend design	As per Table 2-9	At time of mix design
Binder properties at binder production	As per Table 2-9	Certification of each batch/delivery This testing shall apply to the first batch of binder supplied for each project. Subsequent batches be tested for compliance with resilience, softening point and viscosity at 175 °C only.
Binder properties at time of asphalt production	As per Table 2-11	At time of asphalt production
Added filler	As per Table 2-4	Certification of each batch/delivery

Notes:

1. Test only required on river gravels and metasediments
2. Aggregate to be tested for either Los Angeles abrasion loss, or wet strength and wet/dry strength variation

5.3. Process control

The Contractor shall implement process control measures in accordance with or exceeding the requirements in Austroads / AAPA Pavement work tips No. 15 *Asphalt Statistical Process Control.* Statistical process control shall include results for tests in Table 5.1

6. Delivery

Asphalt shall be transported to the point of delivery in vehicles complying with the following requirements:

a. The inside of vehicle bodies shall be kept clean and coated with a thin film of an appropriate release agent to prevent asphalt sticking to the body of the vehicle. Care shall be taken to remove surplus release agent before loading asphalt into the vehicle.
b. After loading with asphalt, the body of the vehicle shall be covered to prevent contamination and reduce the rate of cooling of the mix.
c. Where the length of the haul or the weather is such that the temperature of the asphalt may drop below a suitable placing temperature, or where excessive local cooling of the mix may occur, the vehicles shall be suitably insulated.

7. Placing

7.1. General

Prior to tack coating and placing of asphalt, the surface shall be free of all deleterious material. Where required, the Contractor shall sweep clean the area on which asphalt is to be placed.

The Contractor shall prevent tack coat, binder, aggregate, asphalt or other material used on the work from entering, adhering or obstructing gratings, hydrants, valve boxes, inspection pit covers, kerbs and other road fixtures.

Handwork shall be minimised.

7.2. Tack coating

Tack coat shall be applied to the cleaned surface prior to placing asphalt.

Tack coat shall consist of bituminous emulsion complying with AS 1160. The type and breaking rate shall be suitable to the climatic and surface conditions of use such that it is fully broken, free of surface water and intact before the commencement of asphalt spreading.

Unless otherwise directed, tack coat shall be applied to provide a uniform application rate of residual binder of between 0.15 and 0.25 L/m^2.

Tack coat shall be applied by spray bar fitted to a mechanical sprayer, or purpose-built tack coat spray truck. Hand spraying shall be carried out only in those areas where it is impracticable to use a spray bar.

Precautions shall be taken to protect kerbs, channels, adjoining structures, traffic and parked vehicles from tack coat spray.

Where asphalt is to be spread over clean, freshly placed asphalt, or over a clean primed surface, the Contractor may propose, to the Superintendent, the omission of the tack coat.

7.3. Spreading

Unless otherwise specified, self-propelled mechanical pavers shall be employed to place asphalt except for areas where the use of a paver is impracticable.

Asphalt shall be spread without tearing or segregation.

The Contractor shall conduct spreading operations to ensure that the paver speed matches the rate of supply so that the number of paving stops is minimised.

The paver shall not be left stationary for prolonged periods with the screed box in contact with either the previously placed asphalt or loose asphalt in front of the screed.

The Contractor shall nominate minimum temperature for spreading of asphalt in Project Quality Plan.

7.4. Ambient Conditions for Placing

Unless otherwise approved by the Principal, asphalt shall be placed only when the temperature of the surface on which the asphalt is to be placed is at least 15^{o}C and the ambient temperature at the beginning of placement is at least 13^{o}C. The placement shall be stopped when the ambient temperature is 13^{o}C or less and falling.

Tack coat and/or asphalt shall not be placed when the pavement surface is wet or rain is imminent.

7.5. Layer Thickness

The target thickness of the compacted layer shall be as specified in project particulars.

7.6. Level Control

The method of paver level control shall be as specified in the Schedule of Job Details. If no method is specified in the Schedule of Job Details, the Contractor shall apply suitable automatic or manual screed level controls to achieve the standards specified in Clause 9.

7.7. Compaction

Asphalt shall be uniformly compacted to the standards specified in Clause 9.4 as soon as the asphalt has cooled sufficiently to support the rollers without undue displacement. The Contractor shall nominate minimum temperature for compaction of asphalt in Project Quality Plan.

Compaction shall be achieved using suitable sized steel wheeled or vibratory rollers or a combination of steel wheeled or vibratory rollers. Pneumatic tyred rollers shall not be used.

7.8. Temperature before trafficking

Surface temperature shall be below 65 ºC before opening to traffic.

7.9. Surface gritting

Unless otherwise agreed with the Principal the GGA surface layers shall be gritted.

The grit shall be uniformly spread and rolled into the surface of the hot asphalt during the compaction process. The temperature at which the grit material is applied shall be such that the grit forms a strong bond with, and is partially coated by, the binder in the asphalt mix. The spread rate to be adopted for the grit material shall be nominated by the Contractor and be applied at a rate ≥ 0.2 kg/m^2. After consultation with the Administrator, the nominated spread rate may be adjusted to ensure an adequate coverage of grit is achieved.

Prior to the pavement section being opened to traffic, any loose grit material shall be removed from the road surface.

The material used for gritting shall consist of natural sand particles having a grading complying with the requirements shown in Table 7-1 or other material as approved by the Superintendent.

The grit shall be dry, clean, hard, angular, durable, and free from clay and other aggregations of fine material, soil, organic matter and any other deleterious material.

Table 7-1: Grading limits for grit

AS Sieve Size (mm)	Percentage passing by mass
4.75	100
2.36	90 – 100
0.600	0 - 20
0.075	0 - 0.5

7.10. Joints

7.10.1. General

Joints shall be provided as follows:

a. Longitudinally, if the width of the pavement is such that more than one paving run is necessary.
b. Transversely, after the completion of a day's paving operations, or where a delay in paving operation allows asphalt to cool and adversely affect placing, and elsewhere if a break in a longitudinal run is required.

The location of joints shall be planned before work commences.

The number of joints shall be minimised by adopting good asphalt paving practices.

All joints shall be well constructed and comply with the compaction requirements specified in Clause 8.

7.10.2. Longitudinal Joints

Longitudinal joints in the wearing course shall coincide with traffic lane lines unless otherwise specified or agreed. Longitudinal joints shall be offset from layer to layer by not less than 150 mm provided that no joint is placed directly below a trafficked wheel path.

Where asphalt is placed against the edge of a preceding lane that has not cooled below 80 ºC it shall be considered a hot joint. Hot joints shall be constructed by leaving a 150 mm strip of asphalt unrolled along the free edge until the adjoining lane is placed, and then compacting the unrolled strip simultaneously with the material in the adjoining lane.

Where asphalt is placed against the edge of a preceding lane that has cooled below 80 ºC it shall be considered a cold joint. Asphalt placed against a cold edge should overlap the previous edge by 25 mm to 50 mm. The overlap should be pushed back using lutes, immediately after spreading, to form a slight ridge that is compacted with the steel wheel roller.

7.10.3. Transverse Joints

Transverse joints shall be offset by not less than 1 m from layer to layer.

8. Production control and construction trial

8.1. General

Where a production and construction trial is specified in the Schedule of Job Details, and not less than two days before the site work is due to commence, all the Contractor's plant and personnel proposed for use on the job shall be subjected to a production and construction trial in the presence of the Superintendent. If more than one asphalt mix is specified, each mix shall be subjected to the trial not less than 24 hours before the proposed commencement of production of that mix.

Asphalt manufactured in the production trial may also be used in the construction trial provided that it meets the requirements of the specification.

8.2. Manufacture

The mixing plant shall be operated at approximately the rate intended for full scale production to produce the 50 to 200 tonne of CRM asphalt required for the trial.

The Contractor shall sample and test the asphalt in accordance with Clause 4.9 and the binder in accordance with Table 2-11.

If the tests on the samples indicate that the asphalt does not conform to the Specification, the Contractor shall make such alterations in the procedures or adjustments to the plant and equipment as necessary to produce asphalt in accordance with this Specification. The mixing trial shall be repeated as necessary until asphalt of the quality specified is being consistently produced.

8.3. Placing compaction and finishing

The Contractor shall subject all of the material transfer, placing, compaction and finishing equipment and operating personnel, proposed for use in the works, to a trial using the construction procedures proposed for the work. The trial shall consist of at least two adjacent lanes 3 metres wide and at least 50 metres long and shall be constructed in the designated area, in accordance with all the requirements of this Specification, or as directed.

8.4. Testing of trial section

The Contractor shall test the trial section for the finished pavement properties of this Specification. In the event that the tests indicate that the asphalt in the test section does not conform to the specification requirements, the Contractor shall make any necessary adjustments and, if necessary, repeat the production and construction trials, as specified above, until the

Superintendent is satisfied that asphalt of uniform quality is being consistently produced, placed, compacted and finished in accordance with the requirements of this Specification.

A hold point shall be designated in the Contractor's Quality System at the conclusion of the trial and the Contractor shall not commence full scale production of any asphalt for the works until the hold point has been released.

9. Finished pavement properties

9.1. Lot size

Compliance testing of asphalt shall be undertaken on a lot basis. A pavement lot shall be an essentially homogeneous and contiguous section of work completed within a 24 hour period of production, unless otherwise specified in the Schedule of Job Details

9.2. Level

The level at the top of the asphalt surfacing shall not differ from the specified design level by more than 10 mm, except that where asphalt is placed against kerb and channel, the surface at the edge of the wearing course shall be flush with, or not more than 5 mm above, the lip of the channel, unless otherwise specified or shown on the Drawings.

9.3. Thickness

The average total compacted thickness of the combined asphalt layers shall be not less than the specified thickness and not be greater than specified thickness + 10 mm. Where confirmation of asphalt thickness is required, it shall be determined by coring to a recognised random sampling plan, based on a minimum of 5 cores per lot.

9.4. Surface shape at joints

No point on the finished surface shall deviate by more than 5 mm below a 3 m straightedge, measured between two points across a joint.

9.5. In situ air voids

This clause shall only apply to GGA

Bulk density testing shall not be performed on lots of less than 30 tonnes.

The location of each in situ bulk density test shall be chosen by a method of random stratified sampling. A minimum of 6 bulk density tests shall be performed per lot. For core sample tests, the layer thickness is the mean thickness of the core samples and for nuclear gauge tests, the layer thickness is the nominal thickness. All core holes shall be repaired by an appropriate method.

Density testing shall be carried out as soon as practicable after completion of work. Cores shall be taken in accordance with AS/NZS 2891.1.2. For cores, the bulk density shall be determined in accordance with AS/NZS 2891.9.2. The bulk density from nuclear gauge tests shall be determined in accordance with AS/NZS 2891.14.2

Relative compaction is the percentage ratio of the in situ bulk density of the compacted asphalt and the reference density of the asphalt of a particular lot. The reference density shall be the mean of the five most recent maximum density measurements determined in accordance with AS/NZS 2891.7.1, or AS/NZS 2891.7.3 of the same mix, provided that:

a. The tests have been completed within the previous 4 weeks.
b. The binder content of samples tested is within ±0.3% of the job mix binder content.
c. There has been no change in the mix components or proportions.

The characteristic value of relative compaction is calculated as Mean – K x S where,

Mean = The mean of the relative compaction results

S = The sample standard deviation of the relative compaction results

K = A factor that depends on the number of tests as shown in Table 9.1.

Table 9-1:acceptance constant

Number of Tests or Measurements	Acceptance Constant (K)
6	0.72
7	0.76
8	0.78
9	0.81
10	0.83

The work represented by a lot shall be assessed as the characteristic value of in situ voids where: Characteristic value of in situ air voids (%) = 100 – Characteristic relative compaction.

The maximum characteristic value of in situ air voids shall not exceed 8.0%.

The characteristic value of in situ air voids shall not be less than 3.0%.

The density at the joints is not usually tested unless the Superintendent suspects the specified requirements have not been achieved. Where this occurs, the Superintendent may order tests to confirm compliance.

10. Measurement and payment

This clause shall only apply where not covered elsewhere in the contract for the work

10.1. General

Payment for tack coat shall be included in payment for asphalt.

Payment for asphalt shall be by mass for quantities determined in accordance with Clause 10.2 or 10.3 as appropriate.

Measurement for payment will include all works shown on the plans or as specified but will not include asphalt lost in transit, works not shown on the plans and variations in quantities due to variations in actual thickness exceeding the specified tolerances.

10.2. Measurement by mass

Unless otherwise specified in the Schedule of Job Details, the quantity of asphalt shall be measured by mass (tonnes).

The quantity of asphalt shall be determined from dockets supplied by the Contractor and issued at a certified weighing system unless measurement by batch weights using certified scales is approved by the Superintendent.

Separate pay items shall be included in the Schedule of Rates for each nominal course thickness and each nominal size and type of asphalt specified.

10.3. Measurement by volume

Where specified in the Schedule of Job Details, the quantity of asphalt shall be determined from measurement of area and thickness.

The area and thickness shall be determined from the dimensions on the plans or as specified for the work being measured.

The density of asphalt in a lot shall be taken as the mean of the in situ densities of the lot.

Separate pay items shall be included in the Schedule of Rates for each nominal course thickness and each nominal size and type of asphalt specified.

10.4. Non-complying materials

In the event that the material supplied is not within the tolerances and standards defined for manufacture or placing of asphalt, the Principal may direct:

- The removal of non-complying material; or,
- That the reduced service life arising from the non-complying material is offset by reducing payment for the non-complying material by the method defined in the Schedule of Job Details; or,
- With the consent of the Contractor, any other remedial treatment that is expected to provide the required level of service, or,
- The Contractor to propose a “use as is” disposition where the Contractor can substantiate that the non-conformance will have no adverse impact on the life or performance of the pavement.