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NZTA M27 NOTES: 2020

NOTES TO THE SPECIFICATION FOR STONE MASTIC ASPHALT

1 GENERAL

1.1 Preliminary

These notes are for the guidance of the Engineer and Contractor and do not form part of the contract.

1.2 Scope

The specification has been prepared for the manufacture, supply and placing of Stone Mastic Asphalt mixes, or SMA, surfacing materials.

The nominal maximum aggregate size and types of mixes to be used should be specified in the Schedule of Job Details.

1.3 Quality Systems

It is a requirement that Contractors operate a quality system that complies with AS/NZS ISO 9001 and this quality system is certified by a JAS-ANZ registered agency. In addition, it is expected that Contractors will operate systems such as Civil Contractors New Zealand Asphalt Plant Accreditation Scheme (APAS), or other similar process control programmes.

2 MATERIALS

2.1 Aggregate

Coarse aggregates are specified using the same criteria as for sealing chip in NZTA M06 specification.

The shape and particle size distribution of the coarse aggregate particles affect the packing and consequently the voids in the coarse aggregate structure. Having sufficient voids in the coarse aggregate is critical for accommodating the binder/fines/fibre mastic binder and hence maintenance of the stone-on stone skeletal structure and retention of texture in service. Hence the quality of the coarse aggregates must be very carefully managed by testing to confirm the particle size distribution and particle shape remain consistent.

The relative density (specific gravity) of the aggregate is determined using ASTM C127 for coarse aggregate fractions and ASTM C128 for fine aggregate fractions. Determination of the relative density of the fine aggregates using ASTM C128 normally includes the portion of the fine aggregate passing the 0.075 mm test sieve. However, for some materials removing the portion of fine aggregate passing the 0.075 mm test sieve by washing prior to testing can improve the accuracy of the test result. Appendix X1 of ASTM C128 discusses this practice. Consequently, some testing agencies may choose to wash the fine aggregate when determining the relative density of the fine aggregates.

2.2 Mineral Filler

By strict definition, filler is that mineral matter passing the 0.075 mm sieve and includes filler sized particles derived from aggregates as well as added fine materials such as lime, fly ash, etc. In practice, materials used as added filler are comprised predominantly of particles smaller than 0.075 mm but can also contain a proportion of coarser particles. Tests applied to added filler materials apply to the complete sample, not just that portion passing the 0.075 mm sieve.

2.3 Additives

The binder/filler mastic binder in the SMA mix will drain off the coarse aggregate particles unless additives such as fibres are added to the mix. Generally cellulose fibres are used, and these are added to the mix during the manufacturing process. The fibres are added solely to prevent binder drain down when the mix is hot and do not contribute materially to the in-service performance of the SMA.

The cellulose fibres are usually added as pellets, bound with bitumen, wax, or in some cases, do not contain any binding material. These pellets are metered into the mixing zone in an asphalt manufacturing plant and they open and disperse into the SMA mix during the mixing process.

Experience has shown that some types of plants, such as parallel-flow drum mix plants do not open the pellets as efficiently as other plant types, for example, plants fitted with pugmills or mixing paddles in an external mixing chamber. Consequently, it is recommended that manufacturers consider:

(a) If possible, adjusting the fibre pellet injection point prior to injection of the binder to maximise the aggregate/pellet mixing time;

(b) Adjusting mix production rates to allow adequate time for the fibre pellets to open;

(c) Selecting fibre pellets that open more easily. Some anecdotal evidence suggests that fibre pellets bound with higher levels of bitumen open more easily than other pellets.

Additives to improve workability and aid compaction can also be used. Such additives would be added at the producer's discretion to ensure compliant air voids are achieved in the placed SMA.

2.4 Binder

The binder used in SMA mixes is specified by NZTA M01-A specification. This is a performance-based asphalt binder specification based on AASHTO M 332.

NZTA M01-A uses advanced performance-based testing to link binder properties with site climatic conditions and traffic loading. It is expected that all SMA mixes compliant with M27 will use M01-A compliant binders rather than proprietary polymer modified binders.

There is overlap in binder grades for the "Heavy" category in the Moderate and Warm climate zones. It is expected that engineering judgment and economic criteria will be used by surfacing engineers to select the binder best suited for the location. Contact Waka Kotahi Principal Surfacings Engineer for advice and support if needed.

3 MIX DESIGN

3.1 Layer Thicknesses

SMA mixes depend on an adequate layer thickness to allow formation of the aggregate structure and hence complying in-situ air voids. Specifying layer thicknesses at the minimum level may, in some cases, create practical difficulties in achieving compliant air voids in the field.

It is recommended that layer thicknesses are specified at an optimum level as in Table *3.1* below:

Table 3.1: Optimum Layer Thicknesses for SMA Mixes

Mix Designation	Layer Thickness (mm)	
	Minimum	Optimum
SMA 7	30	35
SMA 10	40	50
SMA 14	55	70

3.2 Design Philosophy

SMA is an asphalt mix that is comprised of a coarse aggregate stone-on-stone skeletal structure, partly filled and bound together with a mastic binder. The mastic is comprised of fine aggregate fractions, a bituminous binder, added filler and commonly fibres.

Properly designed SMA is deformation resistant due to the stone-on-stone coarse aggregate skeleton. The skeleton is bound in place by the stiff mastic binder which fills most of the voids in the coarse aggregate, leaving enough internal voids for binder expansion (4%) and external voids for surface texture. Consequently, optimising the volume of aggregates, filler and binder is critical so that the correct aggregate structure is achieved.

This specification uses AASHTO R 46 to achieve this. Mix designers are expected to use the tools and principles described in R 46 to design a deformation resistant mix that complies with the specified requirements of M27. Appropriate judgement and experience should be exercised by mix designers to develop and optimised SMA mix.

R 46 contains the following main elements:

- Selection and blending of materials

- Optimisation of the blend particle size distribution;
- Selection of design binder content;
- Evaluation of the binder adhesion (or moisture susceptibility), and;
- Evaluation of the binder drain-off.

The procedure in AASHTO R 46 determines if the coarse aggregate stone-on-stone skeleton has been achieved in the SMA mix by:

- Measuring the air voids in the coarse aggregate fraction of the SMA blend by dry rodding, VCA_{drc} (R 46 section 8);
- Calculating the voids in the coarse aggregate fraction in the compacted SMA specimens, VCA_{mix} (R 46 section 9.
- Ensuring that the coarse aggregate voids in the SMA specimens are less than the dry rodded test.

The idea is that, if the volume of fine aggregate plus the binder/fines/fibres mastic are pushing the coarse aggregate skeleton apart, the mix specimen voids in the coarse aggregate will go up, compared with the dry rodded voids.

The primary intent of the mix design process is that the correct aggregate structure is achieved in the SMA mix. It is expected that mix designers will trial several aggregate blends and give careful thought to selecting a blend that is fit for purpose. In some instances, the blend particle size distribution may need to fall outside of the limits of M27 Table 3.1. This is acceptable provided evidence is provided that shows a mix with compliant properties can not be designed within the limits of Table 3.1.

3.3 Laboratory Compaction

Laboratory SMA specimens are made using the Servopac™ apparatus (or equivalent) in accordance with AS/NZS 2981.2.2. This method specifies a compaction angle of 2° or 3° (for 100mm and 150mm diameter specimens respectively), confining pressure of 240kPa and 60 cycles per minute compaction rate. The number of compaction cycles has been raised from previous specifications, from 80 cycles to 120 cycles. The intent is that SMA laboratory specimens will be well compacted to minimise the risk of flushing in service due to post-construction compaction in the field. In addition, the air voids at 250 compaction cycles is fixed at a minimum of 2% in support of this.

As an alternative M27 allows the use of the Superpave gyratory compactor to prepare test specimens in the laboratory. The Servopac™ apparatus can be reconfigured to comply with the Superpave compaction conditions of 1.25° external compaction angle (1.16° internal angle), compaction rate of 30 cycles per minute and a confining force of 600 kPa. Other compaction machines compliant with AASHTO T 312 and/or ASTM D6925 may be used in place of the Servopac™ apparatus. However, the use of the Superpave compaction configuration is subject to agreement with the Engineer.

3.4 Approval of Job-Mix Formula

The Engineer may allow the use of SMA mixes with properties outside the specified ranges where it can be shown that all the other performance requirements can be adequately met. Such departures would normally involve discussions with the client.

A production trial is required to confirm the laboratory mix design and also to identify any necessary adjustments to the mix formulation arising from the scale-up to plant manufacture. It is normal and expected that scaling up to plant manufacture will have an effect on the mix volumetrics and the blend formulation should be adjusted to compensate for this effect. Changes to the proportion of any one component should not exceed 20% of proportion of that component (i.e. a component which comprises 20% of the total SMA mix should not be varied by more than ±4% of the total mix). Where changes greater than 20% are needed, calibration or the operation of the asphalt plant should be checked and validated. If adjustments to the asphalt plant do not correct the mix volumetrics then the mix design should be revalidated in the laboratory.

4 SAMPLING AND TESTING OF SMA PRODUCTION

4.1 General

The purpose of inspection and testing is to provide reasonable assurance to the purchaser that the quality of component materials comply with the standards specified, and that the manufactured SMA is in accordance with the designated job-mix formula.

Manufacturing compliance is assessed by:

(a) Verifying that the job-mix formula has been replicated, i.e. use of conforming components and combination in the design proportions to achieve the job-mix formula grading and binder content, and;

(b) Verification that the mix as produced has compliant volumetric properties.

The manufacturer should not rely solely on the sampling and testing done for compliance purposes as the measures of process quality control. The specification provides an incentive to the manufacturer to undertake suitable measures to improve the level of conformity and consistency of manufactured product by reducing the frequency of testing for compliance purposes where the manufacturer is using a suitable statistical process control system and where the results of compliance tests show an appropriate level of consistency in meeting the specification requirements. A guide to statistical process control systems is provided in AAPA Implementation Guide IG-3: *"Asphalt Plant Process Control Guide"*.

The use of statistical process control and other measures, such as the Civil Contractors New Zealand Asphalt Plant Accreditation Scheme (APAS), are strongly encouraged.

4.2 Volumetric testing

This version of the specification has included the mandatory testing of SMA air voids at manufacture. This is best practice and ensures that field compaction can achieve compliant air voids.

The intention of the specification is that the SMA mix as produced by the asphalt plant will have laboratory air voids at, or close to, the design target. Hence the requirement that the mix production trial should return laboratory air voids at the design target ±1%. It is expected that, if the air voids results fall outside of this criterion that the mix design job-mix formula (i.e. the mix recipe) will be adjusted such that compliant air voids are achieved.

Where routine quality control testing returns volumetric test results that fall outside of the specified limits careful consideration should be given to the degree of non-compliance and the consequent effect on the volumetric properties of the mix in the field; i.e. the in-situ air voids. The breadth of the allowable limits for production air voids (+2.0, -1.0) is relatively wide, so it is expected that if replicable non-compliances are reported then a non-conformance report should be raised, and appropriate corrective actions taken.

See also clause 3.1 above if difficulties in achieving compliant field air voids are encountered.

Where there is dispute over the effect of a volumetric non-compliance and the appropriate corrective actions the advice and guidance of the NZTA Principal Surfacings Engineer should be sought.

5 PLACING

5.1 Preparation of Surface

Road surfaces must be clean to ensure a good bond between new SMA and the existing surface.

5.2 Tack Coating and Waterproofing

Tack coating for normal SMA applications comprises a light application of bitumen emulsion to ensure adequate adhesion between layers. Residual binder application rate is normally between 0.2 and 0.6 L/m² depending on the surface texture and absorption of the substrate. The intention is that a uniform thin layer of bitumen is deposited by the emulsion, without fatty or rich areas which could cause flushing in the SMA. The type of bitumen emulsion for normal applications should suit the conditions of use. Generally, rapid setting cationic emulsion is used in cooler regions where damp conditions may be encountered. In warmer or drier conditions, slower setting cationic emulsions and anionic emulsions may combine easier handling with satisfactory performance.

Tack coating is generally not necessary when placing over newly placed, untrafficked asphalt.

In cases where the existing surface has questionable water resistance a properly designed chip seal should be applied. Common practice has been to apply approximately 1 L/m² with a sparse covering of Grade 4 sealing chip. The binder should not contain volatile diluents (i.e. AGO or kerosene) but adhesion agent should be used to ensure good bonding with a granular substrate and the sealing chip aggregate.

5.3 Spreading

The specification provides for SMA to be placed when pavement surface temperatures are as low as 5°C. Placing in cool conditions increases the difficulty in obtaining good standards of work and, where practicable, work involving thin layers (40 mm or less) should be programmed to be done when such conditions are less likely to occur.

The selection and use of automatic level control for SMA paving should normally be determined by the Contractor, taking into account the applicability to site conditions and the geometric requirements of the finished result. The Schedule of Job Details provides for specification of particular level control devices, if required.

Typical applications of automatic controls are as follows:

(a) *Joint Matcher*. Suitable for use on most classes of work to reduce manual effort.

(b) *Travelling Beam (Generally 9.0 m)*. Assists in removing minor irregularities within the length of the beam. Suitable for a wide range of work, except for short runs and restricted working space. Improved shape correction may involve increased quantities of SMA.

(c) *Cross-fall*. Limited applications where a set cross-fall is desired from a reference on one side of the paver.

(d) *Computerised Electronic Control* (e.g. “Paveset”). Enables paver to operate to predetermined profile. Needs accurate survey and well-maintained equipment.

(e) *Fixed Stringline*. Enables paver to operate to set profile. Requires accurate survey and additional personnel for setting up and maintaining lines. Presence of stringlines can severely restrict movement of spreading vehicles.

5.4 Joints

Joints are the weakest part of the pavement. Cold joints should be minimised by planning of works to achieve a minimum number of construction joints and, where practicable, maximum use of hot or warm joints.

6 CONSTRUCTION TRIAL

A construction trial is usually only applicable to major projects. A separate schedule item should be included for payment for production and construction trials.

7 FINISHED PAVEMENT PROPERTIES

Finished pavement properties requirements are to be specified in contract documents. To date the guidelines specified in the Austroads guide have not been used in New Zealand. NZTA Technical Memorandum TM7003 specifies roughness requirements for finished pavement construction for New Zealand highway pavements.

Where appropriate, compaction of the SMA is measured by determining the pavement air voids by testing core specimens. Locations for testing should be randomly selected, using ASTM D5361 or a similar randomised process, which requires locations to be selected on a stratified random basis. The Engineer may be present during the location selection and sampling process.

If the pavement lot is found to be non-compliant the Engineer should carry out further investigations to confirm the non-compliance. Further investigations should include:

(a) Examination of SMA test results obtained at the plant.

(b) Review of site quality assurance documentation.

(c) Review of environmental conditions during construction.

(d) Visual inspection of core specimens.

(e) Other alternative quantitative methods such as effective porosity and permeability testing.

(f) Visual assessment of the site.

Acceptance of pavement compaction is based on a statistical process. Consequently, taking additional core specimens invalidates this process.

If the non-compliance is confirmed, then the Engineer may direct that:

(g) A reduction in payment proportional to the percent defective, or;

(h) If the actual quality level is significantly outside prescribed limits and is deemed unacceptable the lot should be replaced.

7.1 Testing of Cores

The determination of SMA thickness and compaction is by measurement of core specimen thicknesses and air voids respectively. The compliance of thickness and air voids is determined by a statistical process based on a proportion defective of 10% (consumer’s risk) and a probability of acceptance of 90% (producer’s risk).

Core air voids are calculated from the core Bulk Specific Gravity (relative density) and the Maximum Theoretical Specific Gravity (relative density) using ASTM D3203.

There are four test methods generally used to measure core specific gravity but they return different bulk specific gravities, and consequently air voids, depending on core surface texture and amount of interconnected voids, if any. These methods are ASTM D2726 (water displacement), ASTM D6752 (vacuum sealing), ASTM D1188 (coated specimens) and ASTM D3549 (mensuration).

The default method for determining core density is ASTM D2726. However, this method requires the use of alternative methods for determining specimen volume if core water absorption exceeds the maximum specified level. These alternative methods can return different values for specimen volumes depending on the specimen surface texture. Consequently, the air voids results may include some or all of the specimen surface texture and return higher values than would have been obtained using ASTM D2726 (water displacement).

It is required that testing laboratories report the voids derived from water displacement even if water absorption exceeds the maximum level. This requirement is due to the air voids acceptance criteria being based around voids derived from water displacement. The use of other methods introduces bias into the voids results and could cause compliant SMA to be inappropriately rejected.

Air voids results from cores that exceed the maximum water absorption should be suitably annotated.

Air voids results for core specimens with high absorptions will be biased down as the water can access internal voids within the specimen. Thus, if the Upper Characteristic Value for a set of core air voids results exceeds the maximum allowable value then there is good evidence that the lot is non-compliant and appropriate steps should be taken.

Maximum specific gravity values used to calculate specimen air voids should be derived from the testing of mix from the production lot rather than using values obtained during the mix design process.

Engineers must carefully review and understand the basis of core specimen air voids and if necessary, seek advice from qualified and experienced asphalt technologists so that SMA pavements are not inappropriately accepted or rejected due to test method effects.

It is recommended that core specimens are individually photographed beside a scale rule.

7.2 Ride Quality

The ride quality requirements at roundabouts and intersections shall take into account the design and pre-existing pavement shape and geometrics. Such areas shall be excluded from post-construction roughness testing.

The use of the straight edge is designed mainly for the control of joints on the finished pavement surface but it can also be used where a roughness meter cannot be used due to geometry or length restraints. In these cases, where the Engineer considers that the ride quality is poor, then the straight edge can be used as a more objective measure of poor ride.

8 SPECIAL JOB REQUIREMENTS

If specific job conditions require changes to this specification, special clauses can be prepared and inserted in the Schedule of Job Details for the following:

(a) Any special design requirements, if applicable (specification clause 3.3);

(b) Reporting requirements for mix design tests other than standard volumetric data:

(c) Any special requirements for use of automatic paver control, if applicable (specification clause 9.5.3);

(d) Requirements for a construction trial, if applicable. A separate schedule item is also required for the cost of such trial (specification clause 7);

(e) Special requirements for measurement of ride quality, if applicable. A separate schedule item shall be provided for the cost of testing, where testing is to be provided by the Contractor (specification clause 10.4);