DEPARTMENT *of* INFRASTRUCTURE, ENERGY *and* RESOURCES
TASMANIA ROADWORKS SPECIFICATION

G7 and R55 ASPHALT PRODUCTION & PLACEMENT
EXPLANATORY NOTES
October 2009

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G7 and R55 ASPHALT PRODUCTION & PLACEMENT
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ENR55.1 INTRODUCTION

These explanatory notes are intended to assist those contractors and contract administrators who may be directly involved in the supervision of asphalt roadworks. They have been developed on the basis that those who may be called upon to supervise works involving asphalt products may not have current best-practice understanding of asphalt technology. Whilst those suppliers of asphalt products may have a sound appreciation of asphalt operations, the notes are considered to be of assistance to this group also.

ENR55.1.1 Specifications

The requirements for asphalt products are defined in three linked standard specifications:

- G6 Production of Aggregates and Rock Products. This sets out the minimum requirements for the assessment of a source rock and production quality control, including frequency of testing and recording. It applies to aggregates used in asphalt.
- G7 Production of Asphalt sets out the minimum requirements for the properties of materials to be used in asphalt production, mix design, process control in manufacture and evidence of compliance, records, sampling and testing frequencies during production.
- R55 Asphalt Placement sets out the requirements for the properties and placement of dense graded, stone mastic, open graded and fine gap graded asphalts produced in accordance with G7.

The linkage referred to above requires that:

- Aggregates used in asphalt production are taken from a G6 compliant source and
- Asphalts supplied under R55 are produced in accordance with G7
- Test data produced in accordance with G6 & G7 is collated into control charts and that these charts are readily accessible to the Contractor and Superintendent
- Producers of aggregates and asphalt are to provide samples if required and access to the plant by both the Contractor and Superintendent in order to inspect the plant and documentation.

The specifications try to avoid the specification of method. The intention is to provide sufficient room for the Producer/Contractor to develop efficient and cost effective procedures best suited to his/her business.

The specifications aim to ensure that all the design, production and placement processes are under effective control and that this control can be readily demonstrated through systematically collated and readily available data in the form of control charts. The underlying principle is that well-managed quality control systems provide the best insurance against defective products. Such systems also provide the most effective means of tracking down the source of any non-compliance.

ENR55.1.2 Scope of Standard Specification R55

The specification focuses on the composition of asphalt and the required in-place properties. It covers a number of asphalt types;

- Dense Graded (AC)
- Stone Mastic (SMA)
- Open Graded (OGA)
- Fine Gap Graded (FGGA)

The technical criteria for the four asphalt types are included in individual appendices (A series appendices). Additional appendices include:

- "Determination of Air Voids" Appendix B.
- Required scope of the asphalt element of the Contract Management Plan (Appendix C)
- "Job Mix and Control Limits" Appendix D. This statement is to be completed by the Contractor. It includes a summary of the quality limits that apply for the delivery and placement of the complying Job Mix.

The technical criteria included in the specification are consistent with current Austroads, AAPA and Standards Australia criteria. The specification differs from these authorities with respect to the specifics of quality control processes, evidence of compliance, reporting and in the structure of the specification.

ENR55.1.3 Scope of Explanatory Notes

The Notes are intended to assist those specifying and supervising asphalt works by;

- Describing the functions, features and behaviour of various types of asphalt
- Identifying the issues and limitations involved in design in very broad terms.
- Identifying matters that should be considered in specifying and supervising asphaltic products.

They are intended to provide a starting point for relative new comers to asphalt specification and supervision.

ENR55.2 SELECTION OF ASPHALT

The selection process involves the determination of:

- Asphalt type
- Binder type
- Nominal size of stone

ENR55.2.1 General

The specification covers asphalt that might be used as one of either of, or both of the following functions;

- Wearing course
- Base and intermediate courses.

The wearing course should provide:

- Comfort, smoothness of ride
- Safety, particularly an adequate skid resistance, though wheel spray, glare and visibility might be important

Road noise might also be a significant factor.

Wearing course asphalts may or may not contribute to structural strength (OGAs do not but ACs and SMAs do). Factors determining skid resistance include:

- Resistance to polishing of the exposed aggregate. The extent of polishing will depend on the Polished Aggregate Friction Value (PAFV) of the exposed aggregate, traffic particularly heavy vehicles and the amount of braking and turning
- Surface texture. This becomes of increasing importance at high speeds

Base and intermediate course asphalts (ACs only) are intended to provide stiffness to the pavement. Base course asphalts are required to have:

- Significant stiffness, modulus
- Resistance to fatigue under repetitive tension/flexure
- Resistance to instability under load, (plastic/permanent deformation).

The external factors that largely determine the properties of asphalt are;

- Temperature - The stiffness of asphalt decreases sharply as temperature increases, though fatigue resistance goes in the opposite direction. The significant temperature is the Weighted Mean Average Pavement Temperature (WMAPT) which for most of lowland Tasmania is about 20° C, much less than for most of Australia.
- The stiffness of asphalt falls with decreasing traffic speed
- Stresses applied by traffic, particularly heavy vehicles.

The compositional properties that affect behaviour are mainly:

- Packing and interlock of particles. The significant factors here are the specified properties of particle grading, particle shape and density (resistance to compaction under traffic). Other unspecified factors, such as the roughness and roundness of the particles, are also significant.
- Binder type/stiffness and thickness of coating of binder around particles. Stiffer binders may be appropriate where there are large volumes of slow moving or turning heavy traffic. Thicker coatings generally provide increased fatigue resistance though at the risk of increased instability.
- Voids in mix. With too little and it may be excessively porous. With too much it may be unstable under load and rut and shove and/or lose texture with a resulting loss of skid resistance.

ENR55.2.2 Asphalt Types

The following brief descriptions of the four asphalt types included in the specification are intended only as a starting point towards a more in-depth understanding of asphalt types and their application. There are various Austroads and AAPA publications that deal with the properties, functions and selection of asphalts, including:
Austroads Guide to Pavement Technology:

- *AP-C87/08 Glossary of Austroads Terms;*
- *Part 3 Pavement Surfacings;*
- *Part 4B Asphalt;*
- *Part 4E Recycled Materials;*
- *Part 4F Bituminous Binders;*
- *Part 4H: Test Methods;*
- *Part 4K Seals;*
- *Part 8 Pavement Construction;*
- AP-T68/06 Update of the Austroads sprayed seal design method;
- AP-T41/06 Specification Framework for Polymer Modified Binders and Multigrade Bitumens;
- AP-T42/06 Guide to the selection and use of Polymer Modified Binders and Multigrade Bitumens.

ENR55.2.2.1 Dense Graded Asphalt (AC)

Also known as asphaltic concrete (AC). This is the conventional/universal asphalt. It can be used with the dual functions of a wearing course and base and intermediate course. Dense graded asphalts have a relatively high stiffness, relatively low permeability and texture. The particles are well graded, that is the distribution of particle sizes is such that the voids in the mineral aggregate (VMA) is low.

The high fatigue (AC) base which uses additional binder would be used only at the bottom of a thick asphalt course. In order to avoid rutting, high fatigue base courses should not be used within 125m of surface and should not be more than 70mm thick.

ENR55.2.2.2 Stone Mastic Asphalt (SMA)
This is a high performance wearing course. Relative to AC, an SMA can be expected to provide increased texture, reduced road noise and wheel spray and comparable stiffness, deformation resistance and permeability. The particles are gap graded. Relative to AC, it has more coarse aggregate (retained on 4.75mm sieve). It has more filler (passing 0.075mm sieve) and higher bitumen content. The effect of this is to produce a stiff mastic. It also includes fibre to prevent drainage of the binder during transport. It is not easy to hand work.

ENR55.2.2.3 Open Graded Asphalt (OG)
This is a specialised wearing course product. It is designed to drain freely through high air voids (20% plus compared to less than 5% for the other products). It is gap graded like SMA but does not contain as much filler or binder. In consequence, the voids in the mineral aggregate are not filled and the mix is not as stiff. It outperforms AC's and SMA's with respect to road noise and wheel spray but has relatively low stiffness and should not be used where there is significant braking and turning movements (eg at round-abouts, intersections with lights). Because OGA's are highly permeable, the surface on which OGAs are placed must be impermeable and free of depressions and other obstructions that could lead to the ponding of water within the OGA.

ENR55.2.2.4 Fine Gap Graded Asphalt (FGGA)
These are appropriate to low traffic low speed situations. They are relatively flexible and impermeable and can be placed on relatively flexible foundations.

ENR55.2.3 Selection of Aggregate Size
The attached table provides some general guidance for ACs. The nominal size for SMAs and OGAs would normally be 10mm and occasionally 14mm.

As a rule of thumb, the minimum thickness of a compacted asphalt layer should be at least 3 times the nominal size of the mix. For SMA's the preferred minimum compacted layer thickness is 3.0 to 4.0 times the nominal size. In general the bigger the stone the harsher the product.

Note: The nominal size is essentially the sieve size, expressed in mms at which almost all (90%+) of the aggregate passes.

The other primary considerations are:

- For wearing courses the primary consideration is texture depth (speed environment, stopping distance etc) which, particularly for AC, generally increases with nominal size. It would not be normal to use above 14mm for an AC wearing course
- For base courses it is economy. Generally unit costs decrease with nominal size because binder contents are lower.

Table – Guide to Selection of Nominal Size for AC

Nominal Size (mm)	Typical Layer thickness (mm)	Typical Use
5	15-20	Very thin surfacing with fine surface texture.
7	20-25	Commonly used for surfacing residential streets and foot traffic areas where thin layers and fine surface texture are required. Also for shape corrections.
10	30-35	General purpose wearing course in light and medium traffic applications. Also for shape corrections.
14	40-45	Wearing course mix for heavier traffic applications. Also some intermediate course applications depending on layer thickness.
20	>60	General purpose base and intermediate course mix for wide range of use.
28	>90	Base and intermediate course but less commonly used than 20mm. Control of segregation can sometimes be an issue.
40	>120	Occasionally used as heavy duty base. Control of segregation can be a significant issue.

Note: In general 14mm AC would be used as wearing course. It is unlikely that 28mm and 40mm mixes would be available.

ENR55.2.4 Binder Class / Type

Bitumen classes are based on viscosity. Class 170 refers to a bitumen with a viscosity at 60°C between 140 and 200 Pascal Seconds (Pas). The lower the class, the lower the viscosity (stiffness) of the binder, though flexibility and workability may be improved.

In general Class 170 bitumen is appropriate for all traffic situations in Tasmania. Class 170 bitumen is widely used in sprayed sealing operations and is readily available in Tasmania.

ENR55.2.5 Aggregates and Filler

The specified limits for aggregates are included in G7. They are consistent with AS2758.5 except that the specified minimum and maximum quality limits for;

- Durability
- Flakiness Index
- Polished Aggregate Friction Value (PAFV)

are in terms of an assigned value.(Refer G6 Explanatory Notes).

ENR55.2.6 Important Practical Considerations

While the specification covers a wide range of asphalt types and within each asphalt type there is a range of possible choices concerning nominal size and binder class. It is important to appreciate that:

- The asphalt industry and asphalt plant sizes in Tasmania are relatively small and that all the potential products may not be readily available.
- Hot storage may not be available for special binders (2.4).
- There may be no experience with some potential products. As a result there are likely to be teething problems in production and placement. A better result might be achieved by specifying a commonly used product, one in which there is experience, than in specifying the "ideal" but "untried" product.

ENR55.3 DESIGN OF ASPHALT MIXES

The design procedures for asphalt mixes are defined in G7. By and large it is not necessary for pavement designer/specifier to have an in-depth knowledge of these procedures. The following provides a brief outline.

ENR55.3.1 General

G7 includes two different design methods:

- Marshall
- Austroads

Experience has shown that within a certain range of particle grading and binder contents (target values) that it is possible to produce an adequately functioning asphalt. These target values are included in Appendix A of R55. The basic design task is to:

- Find a blend of available complying aggregates that fall within the target grading range. When compacted the blend must produce a set volume of voids within the mineral aggregate (VMA)
- Determine the amount of binder which satisfies the specified air voids range, film thickness and other criteria.

The procedure will often involve some trial and error changes to the aggregate blend and binder content.

Note: The target grading and target binder contents and tolerances around the job mix are identical for both methods, though the job mix produced by the two methods may not be identical, though they are likely to be similar.

ENR55.3.2 Traffic Categories

The required amount of compaction in both methods is dependent on the projected traffic. Common to both methods are four traffic categories, light, medium, heavy and very heavy. The following table defines these traffic categories.

Table– Guide to Traffic Category

Indicative Traffic Volume		**Traffic Category**	
Commercial Vehicles/lane/day	**STRUCTURAL DESIGN LEVEL**	**Free flowing vehicles**	Stop/start OR climbing lane OR slow moving
<100	$<5x10^5$ ESA	Light	Medium
100-500	$5x10^5$ $5x10^6$ ESA	Medium	Heavy
500-1000	$5x10^6$ $2x10^7$ ESA	Heavy	Very Heavy
>1000	$>2x10^7$ ESA	Very Heavy	Very Heavy

ENR55.3.3 Marshall Method

The Marshall procedure has been the common method of asphalt design for several decades. By and large it has produced an adequate product. The limitations of the method are:

- The properties determined (stability and flow) do not correlate with critical in-service performance factors such as stiffness, resistance to fatigue and permanent deformation.
- The impact, falling hammer, compaction method used in the Marshall procedures is unlikely to provide samples that are suitable to test for in-service performance behaviour. The sample's structure (arrangement of particles) is not likely to replicate field compaction states.

The Marshall test procedure involves the compaction of hot asphalt into a 100mm diameter by 60mm deep mould by a prescribed number of blows of an impact hammer. The number of blows is determined by the traffic category.

The compacted sample is then subjected to compression at 60°C. The maximum compression load is called Marshall Stability and is expressed in kN. The compression undergone at the maximum load is called the flow and is expressed in mm.

The procedure is repeated for a range of binder contents. The appropriate binder content has to satisfy the specified stability, flow, target air voids and binder film thickness criteria.

ENR55.3.4 Austroads Procedures

The Austroad procedures attempt to overcome the limitations of the Marshall method by;

- Employing gyratory/kneading compaction. This is considered to better replicate field compaction and in consequence the samples produced may be better suited for performance testing.
- Directly measuring in-service performance properties, such as modulus, fatigue resistance etc.

The design procedure is summarised in the attached figure (R55 Appendix A). The procedures use three levels of testing;

- Level 1. It applies to all traffic categories. It is roughly equivalent to the Marshall procedure in approach, complexity and application.
- Level 2 and Level 3 tests have no equivalent in the Marshall method. They include a range of "performance" directed tests including
  - modulus/stiffness
  - fatigue
  - creep

At this time there is insufficient experience with the "performance" tests to be able to apply them as criteria in a specification.

ENR55.5 PROJECT SUPERVISION

The following summarises the test requirements relevant to the manufacture and the placement of asphalt. It includes provisions of G7, R40 & R55 relevant to asphalt. It should also be noted that G6 is also relevant, i.e. aggregates must come from a G6 compliant source.

ENR55.5.1 Mix Design and Asphalt Composition

The Contractor is required to provide "a completed and signed Appendix D 0f R55 "Job Mix Compliance and Control Limits" at least five (5) days prior to the intended date of production" (R55.3.4). The completed form provides details of the target grading and binder content, the job mix and tolerance limits. It also includes a summary of the required in-place properties. These should be checked against the requirements of:

- G7, Mix Design Report, Table G7.3 "Information to be included in the Job Mix Design Report".
- Item 1 of the table includes asphalt type, nominal size, design traffic category, mix design methodology and date of tests. The check should include the requirements of the project specification which may cover the above but also binder grade, design method, traffic category, PAFV, Surface Shape R55.5.6.
- Item 3 includes nominated grading, binder content, design air voids and effective film thickness
- Item 6 includes maximum density.

Mix designs have a currency of two years (G7.3.2).

Note: The job mix may be affected by traffic category. However an existing mix may be suitable to use at a different traffic category. The target grading limits and target binder contents by and large do not vary with traffic category, though the design air voids may.

- The relevant "A" series appendix of Spec R55
- The nominated grading must lie within the target grading range. The nominated binder content must also comply.
- The particular design criteria are satisfied. This is likely to include, air voids, effective bitumen film thickness, Marshall Stability and Flow and Voids in Mineral Aggregate VMA. OGA and SMAs must meet drain off tests. SMAs have minimum fibre contents.
- Maximum Characteristic Air Voids

The following provisions are intended to demonstrate evidence of compliance of the product and to monitor the temperature of each truck load. The frequency of testing is dependent on compliance:

- G7, Incoming Materials, Table G7.4.3, "Frequency of Testing of Component Materials". The limits that apply to aggregates and filler are included in Appendix G7A.
- G7, Table G7.4.4 Frequency of Sampling and Testing of Production Asphalt" and G7.4.5 "Monitoring and Control". The producer is required to keep control charts for;
- Grading
- Binder content
- Maximum Density

ENR55.5.2 Delivery and Placement

The successful placement of asphalt requires that:

- The asphalt is at an appropriate temperature, not too cold and stiff that it is too porous and fractures during rolling, or too hot where the binder may have been degraded. Delivery dockets (R55.4.2) require the record of temperature at the point of delivery
- The substrate is sound, will not deform during compaction and is free of volatiles which would soften the asphalt
- All necessary plant and equipment is available (e.g. hand-operated equipment, pavers and compaction plant).

The in- place asphalt is required to comply with:

- Levels (R55.5.2)
- Alignment (R55.5.3) longitudinal joints should not be placed in wheel paths
- Thickness (R55.5.4) for asphalt placed on new works, where the levels of the substrate result from the Contractor's operations
- Air voids criteria (R55.5.5) for AC, SMA and FGGA. Air voids is discussed in a following section.
- Surface shape (R55.5.6) and roughness (R55.5.7) with the appropriate limits defined in the project specification.

ENR55.5.3 Substrate Preparation (R55.4.3)

The specification requires that the Superintendent and Contractor jointly inspect the surface on which the asphalt is to be placed. During this inspection the Superintendent is required to mark out defects in the substrate and define the nature and extent of any required treatment.

The lapsed time between the placement of any bituminous substrate and the laying of the asphalt should be sufficient for volatiles to evaporate.

Where asphalt is to be placed on a newly constructed granular base, the provisions of R40.7.5 "Moisture Content Prior to Sealing" has relevance. The moisture content must not be more than 70% of the corrected OMC.

ENR55.5.4 Production and Construction Trial (R55.4.4)

The location of the trial needs to be discussed with the Contractor. The substrate conditions of the trial should be the same as those proposed for the works.

Details of the trial should be included in the Contract Management Plan. The National Asphalt Specification (AAPA) stipulates the following:

- Minimum size/area of trial
- Number of tests

The Contractor may wish to use the trial to establish the density offset for the in-situ air voids determination.

ENR55.5.5 In-situ Air Voids

The specification places limits on maximum characteristic, in-situ air voids for AC, SMA and FFGA.

In-situ air voids is determined from:

- Reference density (maximum, zero air voids density). The Producer/Contractor is required to maintain control charts for this test.
- In-situ density.

The method of measurement, calculation and reporting details are included in Appendix R55-B "Determination of In-situ Air Voids".

ENR55.5.5.1 Reference Density

The Contractor is required to monitor the maximum density and to maintain control charts (G7.4.5).

The reference density is the mean of the five most recent measurements of the maximum density. A consistent difference between the reference density and the maximum density in the original Job Mix Design Report should be investigated as it is possible evidence of a change in composition.

ENR55.5.5.2 In-situ Density (R55.B.2)

The in-situ density can be determined by either:

- Coring of the asphalt.
- Nuclear density gauge.

Coring can be applied to all layer thickness but leaves a noticeable scar/ blemish.

There are three standard methods of measuring asphalt density gauge:

- A thin lift asphalt gauge (AS2891.14.2) can be used to measure densities in layers varying from 25mm to 100mm in thickness. This is a single purpose device with application only to asphalt.
- Backscatter measurements using a conventional nuclear density gauge (AS2891.14.1.2) in layer thickness varying from 50mm to ???? mm
- Direct transmission measurements (AS2891.14.1.1) using a conventional nuclear density gauge in layers equal to or greater than 75mm. The method involves dulling a 25mm or larger diameter hole.

The backscatter method requires the estimation of a density offset (a correction) that is applied to the meter reading. The method also requires that the derived density offset is monitored by density tests on cores. The required frequency of the checks varies from two tests to every 20 or 40 nuclear gauge readings.

Recognising that a thin layer asphalt gauge may not be available and that most asphalt layers placed in Tasmania will be 50mm and less, the Superintendent may permit the use of a conventional gauge in backscatter mode for layer thicknesses equal to or greater than 35mm.

Note: The offset will depend somewhat on the density of the substrate and needs to be determined on each job and for every change in substrate type (e.g. a change from a Basaltic FCR to a Quartzite FCR could result in a significant change in offset).

APPENDIX ENR55A,

AUSTROADS – APRG REPORT 18 ASPHALT DESIGN PROCEDURES LEVELS 1,2 & 3

Selection & design of asphalt mixes: Australian provisional guide APRG REPORT No. 18

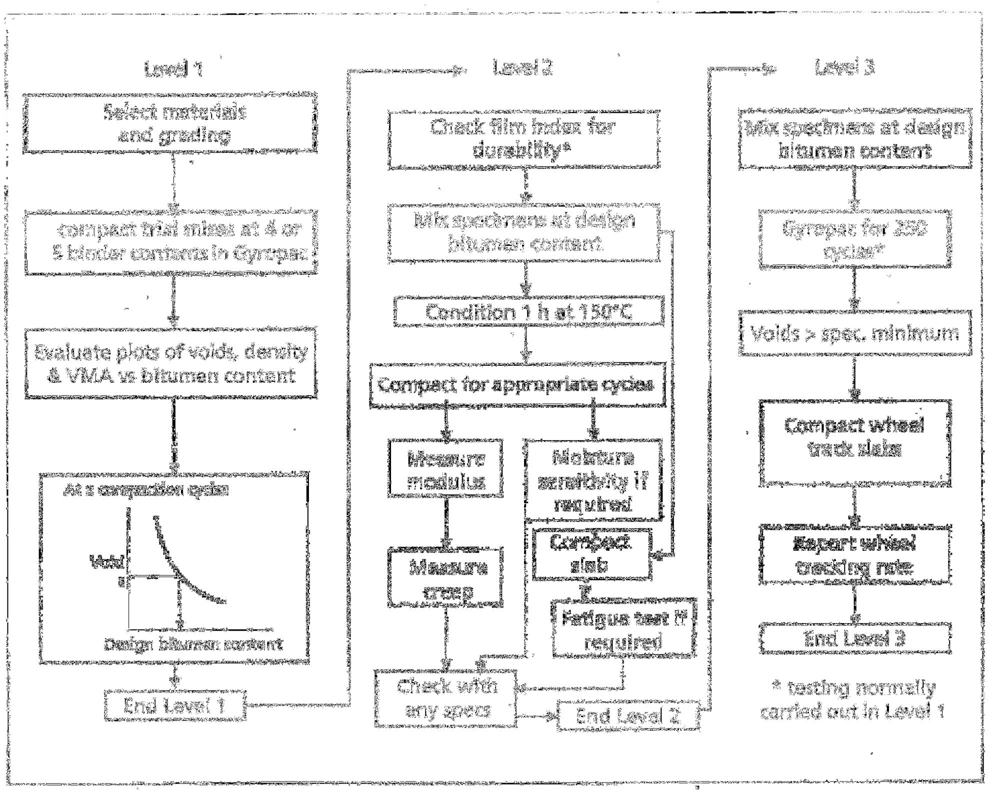

Fig 3.5 Diagram of the asphalt mix design procedure