WAKA KOTAHI
NZ TRANSPORT AGENCY

NZTA M32: 2021

SPECIFICATION FOR HIGH MODULUS ASPHALT (EME 2)

New Zealand Government

1 GENERAL

1.1 Scope

This specification covers high modulus asphalt, commonly referred to as EME Class 2, or EME 2 for roads and related applications.

The areas covered by this specification include:

(a) Constituent materials
(b) Mix design requirements
(c) Process control in manufacture and placement of EME 2
(d) Acceptance criteria for EME 2
(e) Placement of EME 2
(f) Quality systems, minimum process standards, plant requirements, sampling and testing frequencies and measurement and payment.

The requirements of this specification are to be read in conjunction with the schedule of job details. Where there is conflict between the specified requirements and the schedule of job details, the requirements of the schedule shall apply.

1.2 High Modulus Asphalt

High Modulus Asphalt, herein referred to as EME 2, is a high modulus, high fatigue asphalt material that is also resistant to deformation. It is used in heavy duty situations where a structural asphalt layer is needed. Due to its high stiffness sometimes a reduced layer thickness compared with conventional structural asphalt materials may be used. EME 2 is not normally used as a wearing course, or upper, layer in a pavement because of its low texture.

EME 2 uses normal aggregate materials bound with a specialised stiff, deformation resistant binder. It is designed in the laboratory using specialised equipment and characterised by volumetric and performance-related testing.

1.3 References

1.3.1 Waka Kotahi NZ Transport Agency

(a) NZTA M06	Specification for Sealing Chip
(b) NZTA Q05	Specification for Minimum Standard for Bitumen Quality
(c) NZTA T20	Ethylene Glycol Accelerated Weathering Test
(d) NZTA T22	Quantitative Extraction of Binder from Asphalt Mixes
(e) NZTA	Chipsealing in New Zealand

1.3.2 Austroads

(a) AGPT-T212	Gyratory Compactor Test Method
(b) AGPT-T220	Sample Preparation - Compaction of Asphalt Slabs
(c) AGPT-T231	Deformation Resistance of Asphalt Mixtures by the Wheel Tracking Test
(d) AGPT-T274	Characterisation of Flexural Stiffness and Fatigue Performance of Bituminous Mixes

1.3.3 Standards New Zealand

(a) NZS ISO/IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories
(b) NZS 4407	Methods for Sampling and Testing Aggregates
(c) AS/NZS ISO 9001	Quality Systems – Requirements
(d) AS/NZS 2341.2	Determination of Dynamic Viscosity by Vacuum Capillary Viscometer
(e) AS/NZS 2341.4	Determination of Dynamic Viscosity by Rotational Viscometer
(f) AS/NZS 2341.8	Determination of Matter Insoluble in Toluene

(g) AS/NZS 2891.3.3	Bitumen Content and Grading – Pressure Filter Method
(h) AS/NZS 2891.14.2	Methods of Sampling and Testing Asphalt - Field Density Tests, Backscatter Mode

1.3.4 Standards Australia

(a) AS 1141.5	Particle Density and Water Absorption of Fine Aggregate
(b) AS 1141.6	Particle Density and Water Absorption of Coarse Aggregate
(c) AS 1141.11	Particle Size Distribution – Sieving Method
(d) AS 1141.22	Wet/dry Strength Variation

1.3.5 American Society for Testing and Materials (ASTM)

(a) ASTM C117	Materials Finer Than 75-μm Sieve in Mineral Aggregates by Washing
(b) ASTM C127	Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
(c) ASTM C128	Density, Relative Density (Specific Gravity) and Absorption of Fine Aggregate
(d) ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
(e) ASTM D5	Penetration of Bituminous Materials
(f) ASTM D36	Softening Point of Bitumen (Ring-and-Ball Apparatus)
(g) ASTM D70	Density of Semi-Solid Bituminous Materials (Pycnometer Method)
(h) ASTM D140	Standard Practice for Sampling Asphalt Materials
(i) ASTM D242	Standard Specification for Mineral Filler for Bituminous Paving Mixtures
(j) ASTM D979	Sampling of Bituminous Paving Mixtures
(k) ASTM D2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
(l) ASTM D2042	Solubility of Asphalt Materials in Trichloroethylene
(m) ASTM D2171	Viscosity of Asphalts by Vacuum Capillary Viscometer
(n) ASTM D2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
(o) ASTM D2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
(p) ASTM D2872	Effect of Heat and Air on a Moving Film of Asphalt (Rolling Thin-Film Oven Test)
(q) ASTM D2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
(r) ASTM D3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
(s) ASTM D3549	Thickness or Height of Compacted Bituminous Paving Mixture Specimens
(t) ASTM D4402	Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer
(u) ASTM D4867	Effect of Moisture on Asphaltic Concrete Paving Mixtures
(v) ASTM D5361	Sampling Compacted Bituminous Mixtures for Laboratory Testing
(w) ASTM D5444	Mechanical Size Analysis of Extracted Aggregate
(x) ASTM D6307	Asphalt Content of Hot-Mix Asphalt by Ignition Method
(y) ASTM D8159	Standard Test Method for Automated Extraction of Asphalt Binder from Asphalt Mixtures

1.3.6 Miscellaneous

(a) AASHTO T 329	Moisture Content of Asphalt Mixtures by Oven Method
(b) AASHTO T 350	Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR).
(c) CCNZ BPG05	Quality Assurance of Aggregates.

1.4 Quality System

The Contractor shall establish, implement and maintain a quality system in accordance with this specification and the requirements of AS/NZS ISO 9001, or a recognised equivalent. The quality system shall be certified and regularly audited by a JAS-ANZ registered agency

The Contractor shall submit a quality plan prior to commencement of any works. The quality plan shall consider 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 or this specification.

1.5 Testing

All sampling and testing required by the specification shall be undertaken in a laboratory accredited to NZS ISO/IEC 17025.

2 MATERIALS

2.1 Aggregate

2.1.1 General

Coarse aggregate shall consist of crushed stone or crushed gravel produced from hard durable rock or river boulders.

Fine aggregate shall consist of particles of crushed stone or crushed gravel or a mixture of these materials. Natural sand or uncrushed fine aggregate shall not be used.

Testing frequency shall be in accordance with CCNZ BPG05 Quality Assurance of Aggregates.

2.1.2 Coarse Aggregate

Coarse aggregate is comprised of particles that are retained on the 4.75 mm sieve. Coarse aggregate shall comply with the requirements of Table 2.1.

Table 2.1 Coarse Aggregate Requirements for Dense Graded EME 2 Asphalt

Test Property	Test Method	Requirements
Crushing Resistance	NZS 4407 Test 3.10	< 10% Fines @ 200kN
Weathering Quality Index	NZS 4407 Test 3.11	AA or BA
Single Broken Faces	NZS 4407 Test 3.14	98% minimum
Two Broken Faces	NZS 4407 Test 3.14	60% minimum
Wet/Dry Strength Variation	AS 1141.22	35% maximum
Ethylene Glycol Accelerated Weathering	NZTA T20	30% maximum
Bulk SG and Density	ASTM C127 or AS 1141.6	Report
Absorption	ASTM C127 or AS 1141.6	Report

Notes:

(a) The Single Broken Faces and Two Broken Faces testing is not required for aggregate derived from a non-alluvial “hard rock” quarry. In that instance the Broken Faces criterion is assumed to be 100%.

(b) If the aggregate exceeds the maximum requirement for the Ethylene Glycol Accelerated Weathering Test, further testing to detect the presence of smectite clays may be carried out using X-ray diffraction. If the aggregate is shown to be free of smectite clays it may be considered compliant with this criterion. Refer to Waka Kotahi Lead Advisor Pavements or Principal Surfacings Engineer for guidance and direction if specified requirements are exceeded. Refer to M32 Notes.

2.1.3 Fine Aggregate

Fine aggregate shall consist of 100% crushed rock particles finer than the 4.75mm sieve and manufactured from a source complying with the requirements of Table 2.2.

The fine aggregate shall be clean, hard, durable and free from pumice and lumps of clay and other aggregations of fine materials, organic material and any other deleterious material.

Table 2.2 Fine Aggregate Requirements

Test Property	Test Method	Requirements
Crushing Resistance	NZS 4407 Test 3.10	< 10% Fines @ 200kN
Sand Equivalent, or	NZS 4407 Test 3.6	35 minimum, or
Clay Index (<0.075 mm)	NZS 4407 Test 3.5	3.0 maximum
Bulk SG and Density	ASTM C128 or AS 1141.5	Report
Absorption	ASTM C128 or AS 1141.5	Report

Notes:

(a) Crushing resistance for fine aggregates is carried out on the parent rock used for the manufacture of the fine aggregates.
(b) The fine aggregate is defined as the fraction of the blended aggregate passing the 4.75mm sieve excluding added mineral filler (if any).

2.2 Mineral Filler

Mineral filler is that portion of mineral matter predominantly passing a 0.075mm 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.

Filler shall be consistent in mineral composition. It shall be dry, and free from lumps, clay, organic matter or other material deleterious to the EME 2 mix.

Added mineral filler (material not derived from the aggregate components) shall comply with ASTM D242.

2.3 Binder

The binder shall be bitumen complying with the requirements of Table 2.3 below. The binder supplier shall provide documentation demonstrating compliance of the binder with the requirements of Table 2.3 below.

The binder shall be sampled using the method of ASTM D140 (or equivalent). Binder sampling frequency shall be in accordance with NZTA Q05. Indicator tests may be used by the EME 2 supplier to demonstrate continued compliance with Table 2.3. As a minimum they shall be Penetration and Softening Point.

Table 2.3 Requirements for EME 2 Binder

Property	Test Method	Requirements	
		10/20 Grade	15/25 Grade
Penetration (100g, 5s, 25°C) ($\frac{1}{10}$mm)	ASTM D5	10 - 20	15 - 25
Softening Point (°C)	ASTM D36	59 – 79	56 - 72
Density (kg/m³)	ASTM D70	Report	Report
Viscosity at 60° C (Pa·s)	ASTM D2171 AS/NZS 2341.2	1050 minimum	900 minimum
Viscosity at 135° C (Pa·s)	ASTM D2171 ASTM D4402 AS/NZS 2341.2 AS/NZS 2341.4	0.7 minimum	0.6 minimum
Rolling Thin-Film Oven Test Mass Change (%)	ASTM D2872	Report	0.5 maximum
Retained Penetration (%)	ASTM D5	Report	55 minimum
Increase in Softening Point (°C)	ASTM D36	10 maximum	8 maximum
Multiple Stress Creep Recovery (kPa^{-1})	AASHTO T350	Report	Report
Solubility: Trichloroethylene, or (%)	ASTM D2042	99.5 minimum	99.5 minimum
Toluene (%)	AS/NZS 2341.8	Report	99.0 minimum

Notes:

(a) Either ASTM D2171 or AS/NZS 2341.2 can be used to determine the viscosity at 60°C. The Asphalt Institute design capillary tubes shall be used.
(b) Either ASTM D2171, ASTM D4402, AS/NZS 2341.2 or AS/NZS 2341.4 can be used to determine the viscosity at 135°C.
(c) The mass change after the Rolling Thin Film Oven test can either be a negative number (a mass loss) or a positive number (a mass gain). The absolute value of the mass change shall be used to determine compliance with the mass change criterion.
(d) Either ASTM D2042 or AS/NZS 2341.8 can be used to determine the solubility. Report the percentage soluble. For AS/NZS 2341.8 the percentage soluble is 100 less the matter insoluble in toluene.
(e) The Mass Change, percentage Retained Penetration and Solubility in Toluene criteria have not yet been established for the 10/20 binder grade. These criteria are to be reported only.
(f) Unless otherwise specified carry out the Multiple Stress Creep Recovery test at 64°C.

2.3.1 Additives

Additives, such as anti-stripping (adhesion) agents or warm-mix asphalt additives may be used in EME 2. The type and proportion of additives to be used in the mix, other than those specified elsewhere in this specification, shall be in accordance with an approved specification. An approved specification may be a manufacturer's recommendation, purchaser's specification or as agreed between the parties.

If additives are incorporated in the EME 2 asphalt mix then the performance-related testing of clause 3.4 following shall be carried out on EME 2 samples containing the additives.

2.4 Reclaimed Asphalt Pavement

Up to 15% of reclaimed asphalt pavement (RAP) may be used in the EME 2. If RAP is to be used in the EME 2, the mix design and associated performance testing shall be carried out with the RAP included in the EME 2 mix.

If RAP is incorporated in the EME 2 asphalt mix then the performance-related testing of clause 3.4 following shall be carried out on EME 2 samples containing the RAP.

The RAP shall be crushed and screened as necessary to ensure a maximum size no greater than the nominal size of asphalt being produced. Fine, "all-in" grades shall be well graded, free flowing and consistent. Coarser RAP fraction may be more uniformly graded.

RAP shall only be used from stockpiles that have been tested for consistency in particle size distribution and binder content. Maximum specific gravity (ASTM D2041) may also be advisable if the stockpile contains RAP from different sources.

RAP component(s) shall be metered into the plant in such a way that the RAP binder is not damaged or excessively hardened by exposure to the plant heating system (i.e. burner flame).

3 MIX DESIGN

3.1 General

The Contractor shall provide all mix designs. The Contractor's mix design shall be assessed by the Engineer for compliance with the requirements of this specification. The Engineer's approval of the mix design is a prerequisite for its use.

3.2 Particle Size Distribution

The particle size distribution for the combined aggregates and filler shall be 100% passing the 19.0mm test sieve. There are no other requirements for the EME 2 particle size distribution.

The particle size distribution established during the mix design process shall be reported.

3.3 Volumetric Properties

EME 2 asphalt shall be designed in the laboratory and trial specimens prepared in accordance with AGPT T212 Table 1 using the following conditions:

(a) The vertical loading stress shall be 600 ± 18 kPa;
(b) The internal compaction angle shall be 0.82° ± 0.02°;
(c) The rate of compaction shall be 30 ± 0.5 gyrations per minute.

Specimens shall have a nominal diameter of 150mm and a height of 115 ± 5 mm. Compaction effort shall be 100 gyratory cycles using the test conditions listed above.

EME 2 compaction temperature shall be at a binder viscosity of 0.28 ± 0.03 Pa·s, including any additives (note that this differs from T212 section 5).

The specimen air voids shall be determined using the method of ASTM D2726 and ASTM D3203. At least three specimens shall be prepared for each binder content trial. The air voids averaged for the three specimens at the selected design binder content shall fall between 4.0% and 3.0%.

The EME 2 shall have a minimum binder content such that the Richness Modulus (K) is greater than 3.4. The Richness Modulus is calculated from the formula below:

$$K = \frac{\left(\frac{100B}{100 - B}\right)}{\alpha \sqrt[5]{\Sigma}}$$

Where:

B = Binder content (% by mass of the total asphalt mix)
α = $\frac{2.65}{\rho_a}$, where ρ_a = bulk oven-dry particle density of the combined mineral aggregate (t/m^3)
Σ = $(0.25G + 2.3S + 12s + 150f)/100$, where:
G = Percentage of aggregate particles greater than 6.30 mm
S = Percentage of aggregate particles between 6.30 mm and 0.250 mm
s = Percentage of aggregate particles between 0.250 mm and 0.075 mm
f = Percentage of aggregate particles less than 0.075 mm.

G, S and s may be interpolated using a linear relationship from the grading curve using standard sieves.

3.4 Performance-Related Properties

All performance related testing shall be carried out at the laboratory mix design binder content. The EME 2 asphalt shall comply with the requirements of Table 3.1 and the associated notes. The reported value for the flexural stiffness shall be used to determine the thickness of the EME 2 layer.

Table 3.1 Performance-Related Property Requirements for EME 2 Asphalt

Property			Test Method	Requirements
Effect of Moisture (Tensile Strength Ratio)		(%)	ASTM D4867	75 minimum
Wheel Tracking:			AGPT-T231	-
60°C, 5,000 cycles (10,000 passes)		(mm)		2.0 maximum
60°C, 30,000 cycles (60,000 passes)		(mm)		4.0 maximum
Flexural Stiffness: 50 ± 3 με, 15°C, 10Hz		(MPa)	AGPT-T274	9000 minimum
Fatigue Resistance:	20°C, 10Hz, 10^6 cycles	(με)	AGPT-T274	150 minimum
	Stiffness reduction	(%)		50 maximum

Notes:

(a) The freeze/thaw requirements of ASTM D4867 are mandatory.
(b) Specimens for wheel tracking shall be compacted to an air voids content of 3 ± 1.0% as determined by ASTM D2726 and ASTM D3203. At least two specimens shall be tested, and the wheel tracking rut depth reported as the average result for the test specimens.
(c) Sinusoidal loading shall be used for the determination of the flexural stiffness and fatigue Resistance. The flexural stiffness shall be reported as the average result for at least four beams.
(d) If the flexural stiffness is less than 9000 MPa then adjustments shall be made to the EME 2 placement depth to compensate for the reduced stiffness.
(e) The failure criterion for fatigue resistance testing to AGPT-T274 shall be the number of cycles at which the beam stiffness reaches 50% of the initial stiffness.
(f) Inclusion of the plots of data and graphs and results of equipment check as in AGPT-T274 10.8 (d) is mandatory.
(g) Reporting of all of the “Optional information” of AGPT-T274 11.8 (d) is mandatory.
(h) Fatigue resistance testing shall follow AGPT-T274, except for the purpose of mix design, only one sinusoidal strain value of 150 microstrain at 10Hz and 20°C shall be tested on four beams only to 1 million load cycles and the percentage of stiffness reduction shall be reported for each beam tested. Compliance is achieved when all 4 beams tested result in a stiffness reduction of less than 50% after 1 million load cycles. Although not required for mix design, Waka Kotahi projects using the EME 2 mix will require a full suite of beam fatigue tests at three different strain levels repeated six times totalling 18 beams as per AGPT-T274. Testing shall be at one temperature only (20°C or one other specified temperature) to obtain the pavement design fatigue relationship.

3.5 Approval of Laboratory Mix Design

3.5.1 Laboratory Mix Design

The Contractor shall provide the information listed below for approval by the Engineer at least seven days prior to commencement of production:

(a) Properties of constituent materials required under this specification including aggregates, filler, binder, additives (if used) and source of materials;
(b) Test results of trial mixes made in the laboratory at varying binder contents to arrive at the design mix;
(c) Test results in accordance with the design requirements specified in clauses 2 and 3 of this document, either directly measured or interpolated, including:
    i. The blend ratios of the individual aggregate components;
    ii. The added filler content (if used);
    iii. The type, source and quantity of additives (if used);
    iv. The aggregate blend particle size distribution;

v. The bulk specific gravity and density of the aggregate components and combined aggregates;
vi. The design binder grade, density and content;
vii. The RAP content and properties including particle size distribution and binder content (if used);
viii. The specimen compaction temperature;
ix. The bulk specific gravity and density of the mix for each trial blend;
x. The maximum specific gravity and density of the mix for each trial blend;
xi. The air voids of the compacted mix for each trial blend;
xii. The VMA of the compacted mix for each trial blend;
xiii. The effective design binder content by volume (Vbe);
xiv. The tensile strength ratio at design binder content;
xv. The rut depths determined by the wheel tracking test at the design binder content;
xvi. The flexural stiffness at 15°C;
xvii. The flexural modulus and percentage stiffness reduction and microstrain at 20°C and 1 million cycles;

3.5.2 Production Trial

The following test results performed on a batch of the EME 2 mix proposed to be used, and produced from the mixing plant for design verification from which the asphalt is to be supplied:

(a) The particle size distribution;
(b) The total binder content;
(c) The RAP content (if used);
(d) The maximum specific gravity of the mix;
(e) The bulk specific gravity and density of the compacted mix;
(f) The air voids at laboratory design compaction level;

The scale-up of manufacture from the laboratory to the plant affects mix volumetric properties. It is normal that asphalt mix blend adjustments are made following mix design validation trials to optimise the mix as produced by the plant. Such adjustments shall be documented in the mix design report.

Changes to individual components of the asphalt mix shall not exceed 20% of the proportion of that component (i.e. a component representing 20% of the total asphalt mix shall not be adjusted to below 16% or 24% of the total asphalt mix). Refer to the Notes for guidance where significant proportion changes are found to be necessary.

3.5.3 Approval Criteria

Approval of the job mix formula will be granted if the following criteria are met:

(a) Constituent materials comply with the specified requirements;
(b) The volumetric properties of the EME 2 asphalt obtained during the laboratory mix design process at the nominated design binder content, whether directly measured or interpolated, comply with the specified criteria;
(c) The performance-related properties of the EME 2 asphalt at the nominated design binder content, whether directly measured or interpolated, comply with specified criteria;
(d) The particle size distribution of the plant-produced EME 2 complies with the envelope constructed by applying the tolerances of Table 5.3 to the mix design particle size distribution curve;
(e) The binder content of the plant-produced EME 2 complies with the limits derived by applying the tolerances of Table 5.3 to the mix design binder content;
(f) The average air voids for three test specimens compacted from plant produced EME 2, compared with the mix design air voids and following any adjustments, fall between ±1.0% of the mix air voids established in the mix design process. If the air voids for the plant-produced mix do not fall within these limits, then appropriate adjustments should be made to the mix design and/or the production process and the production trial repeated.

On request all test results must be supplied with the results showing the unrounded calculations followed by the rounded values to the accuracy required in the test specifications.

3.5.4 EME 2 Mix Design Validation

EME 2 mix designs shall be valid for six months from the date of the production trial. Validation shall be extended where testing no more than six months old confirms:

(a) The EME 2 particle size distribution complies with the requirements of clause 5.3 below, and;
(b) The EME 2 binder content complies with the requirements of clause 5.3 below, and;
(c) Volumetric testing confirms that the air voids of the EME 2 complies with the requirements of clause 5.3 below, and;
(d) The type, quality, proportion and sources of all constituent materials remain substantially unchanged. Substantially is defined as 20% or less of the mass percentage of the constituent material (i.e. for a constituent with a design proportion of 20%, the proportion of that constituent shall not be less than 16% nor more than 24%);

Where there are no compliant test results within the last six months, or if the proportion of constituent materials require a change greater than 10% of that component, the following steps may be taken to revalidate the mix design:

(a) A sample of EME 2 is prepared in the laboratory to confirm the compliance of the volumetric properties of the asphalt mix, or;
(b) The EME 2 is validated by a production trial as in clause 3.5.2 above.

Where there are no compliant test results within two years of the production trial the EME 2 mix design shall no longer be valid.

3.5.5 Approval to Use Previously Designed Mix

The Engineer shall accept a previously approved mix design used by the Contractor under other contracts for the supply of EME 2 subject to the following conditions:

(a) The conditions of clause 3.5.4 are met, and;
(b) The in-service performance in terms of deformation and cracking of the EME 2 is considered to be satisfactory by Waka Kotahi.

4 MANUFACTURE AND STORAGE

4.1 General

Asphalt manufacturing plant shall be of sound design and construction and capable of consistently producing EME 2 mixes with the properties specified and at a rate suitable for smooth, continuous placement.

4.2 Storage of Raw Materials

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) RAP shall be placed in separate stockpiles prior to use.
(c) 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.
(d) Additives shall be protected from moisture or contamination. Materials that are contaminated or moisture-damaged shall not be used.
(e) Tanks for heating and storage of binder shall be thermostatically controlled and each shall be fitted with a thermometer that is located so that the temperature can be read conveniently. EME 2 binder shall not be heated to more than 190°C.

4.3 Mixing Temperatures

Temperature of bitumen and aggregates at the mixing plant, and the temperature of EME 2 as it is discharged from the production plant, shall be specified in the quality plan. EME 2 discharge temperatures shall not exceed 190°C unless specifically permitted by the Engineer in writing.

Continuous records of the mix temperature at discharge from the mixer shall be maintained. These records shall be made available for audit by the Engineer.

4.4 Moisture Content

After completion of mixing, the moisture content of the EME 2 shall not exceed 0.5%.

4.5 Storage of EME 2

EME 2 can be stored prior to delivery to the purchaser, subject to the following requirements being observed.

(a) The mix can be stored in an insulated storage bin.
(b) The Contractor shall nominate in the quality plan the maximum storage time appropriate to the contract and production plant.

5 SAMPLING AND TESTING OF EME 2 PRODUCTION

5.1 General

The Contractor shall arrange for all relevant testing.

Samples from EME 2 production shall be randomly selected (random sampling) using a recognised statistical technique from fresh production mix at the asphalt plant. Separate samples shall not be combined. All test results of samples associated with a specific contract shall be reported to the Engineer.

Production EME 2 shall be tested for the following:

(a) Particle Size Distribution.
(b) Binder Content.
(c) Maximum Specific Gravity (for monitoring changes in aggregate properties and use in calculating laboratory test specimen and core air voids).
(d) Air voids as an average of three test specimens compacted from the plant-produced mix.

5.2 Frequency of Sampling and Testing

Unless otherwise specified, or agreed, frequency of sampling and testing shall be not less than that shown in Table 5.1 and Table 5.2 with a maximum of three samples per production lot. Acceptance of the mix will be based on lots. A production lot will normally consist of a day's or a shift production or as detailed in the Contractor's quality plan. When a day's output is less than 100 tonnes and the same asphalt mix is to be produced on subsequent days for the same pavement section, the lot considered for acceptance will include the next day's production.

Table 5.1 Minimum Frequency of Testing of Component Materials

Test	Minimum Frequency
Binder Testing (Penetration, Softening Point, Viscosity)	As per NZTA Q05
Particle Size Distribution	As per CCNZ BPG 05
Broken Faces (blend fraction coarser than 4.75mm)	As per CCNZ BPG 05
Aggregate fines quality (Sand Equivalent or Clay Index on blend fraction passing 4.75mm)	As per CCNZ BPG 05
Crushing Resistance	As per CCNZ BPG 05
Weathering Resistance	As per CCNZ BPG 05
Density and Absorption of Aggregates	As per CCNZ BPG 05
Added Filler	Certification from the supplier
RAP Particle Size Distribution and Binder Content	One test per 600 tonnes of RAP

Note: Binder testing shall be at least Penetration, Softening Point and Viscosity at 60° C.

Table 5.2 Minimum Frequency of Sampling and Testing of Production Asphalt

Test	Normal Minimum Frequency
Particle Size Distribution	One test per 200 tonnes of production
Binder Content	One test per 200 tonnes of production
Maximum Specific Gravity	One test per 200 tonnes of production
Air Voids	One test per 600 tonnes of production

5.3 Production Tolerances

Production tolerances for individual test results for particle size distribution, binder content and production air voids shall comply with Table 5.3. The tolerances are applied to the values obtained during the mix design process.

Where a project or a job requires three or more tests, a rolling average of the particle size distribution, binder content and air voids test results shall be calculated. The rolling averages shall fall within the limits formed by applying the “percentage mean of three” tolerances of Table 5.3 to the values obtained during the mix design process.

Table 5.3 Production Tolerances for EME 2

Description	Maximum Tolerance on Job-Mix Formula	
	Percentage for Individual Test Results	Percentage Mean of Three Test Results
Sieve size one size larger than nominal size	Nil	Nil
1.18mm sieve and larger	± 8	± 5
0.600mm, 0.300mm sieves	± 6	± 4
0.150mm, 0.075mm sieves	± 3	± 2
Binder Content: Percent by Mass	± 0.5	± 0.3
Air voids	+2.0, -1.0	+1.2, -0.6

5.4 Process Control

The Contractor shall implement suitable measures for control of the EME 2 manufacturing process. Process control measures can include the use of statistical process control charts for some, or all, of the tests required in Clause 5.2, and suitable decision rules for determining that the process is under statistical control.

6 DELIVERY

EME 2 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 the EME 2 sticking to the body of the vehicle. Care shall be taken to remove surplus release agent before loading EME 2 into the vehicle.
(b) After loading with EME 2, suitable covers shall be used 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 EME 2 may drop below a suitable placing temperature, or where excessive local cooling of the mix may occur, the vehicles shall be suitably insulated.

7 CONSTRUCTION TRIAL

7.1 General

Where a construction trial is specified in the contract, 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 carry out a construction trial in the presence of the Engineer. EME 2 manufactured in the production trial can also be used in the construction trial if it meets the requirements of the specification.

7.2 Manufacture

The mixing plant shall be operated at approximately the rate intended for full-scale production to produce the following quantities.

Sufficient EME 2 shall be produced to give two paver runs at least 30 metres long, placed at specified thickness with at least one longitudinal joint.

The Contractor shall sample and test the EME 2 in accordance with clause 5. Unless otherwise specified, constituent (binder content and particle size distribution) and air voids testing shall be carried out to confirm the properties of the produced mix.

If the tests on the samples indicate that the EME 2 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 EME 2 in accordance with this specification. The trial shall be repeated as necessary until EME 2 of the quality specified is being consistently produced.

7.3 Placing, Compaction and Finishing

If specified in the contract the Contractor shall subject all of the 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 30 metres long, and shall be constructed in the designated area, in accordance with all the requirements of this Specification, or as directed.

The joint between the lanes shall be a warm joint where the temperature of EME 2 at the first run edge is greater than 60°C. Otherwise, the joint is a cold joint and is to be treated as detailed in clause 9.6.2.

7.4 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 EME 2 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 Engineer is satisfied that EME 2 of uniform quality is being consistently produced, placed, compacted and finished in accordance with the requirements of this specification. Testing shall include in-situ air voids and mat thickness by drilling and testing core specimens.

A hold point shall be designated in the Contractor's quality system at the conclusion of the trial (unless agreed with the Engineer) and the Contractor shall not commence full-scale production of any EME 2 for the works until the hold point has been lifted.

8 CONTRACTOR QUALITY PLAN

8.1 General

The quality management plan shall include the following items.

8.2 Raw Materials

The quality plan shall outline the way in which raw materials, including RAP if used, in the produced EME 2 are managed. This shall include such items as required tests and test frequency, handling and storage.

8.3 Mix Design and Production Trials

This quality plan shall outline the mix design procedure adopted and the process in which production trials, lay down trials (if required) will be completed including how compliance will be assessed.

8.4 Sampling and Testing

The quality plan shall describe the way in which sampling and testing is used to determine compliance of material. This will include detailing the time in which the random sample locations will be chosen. The section should include how non-conformances will be dealt with.

8.5 Manufacturing, Storage and Transportation

The quality plan shall specify the following:

(a) Discharge temperatures from the plant, or the storage facility including rejection limits.
(b) Storage durations. Where an asphalt plant has the ability to store the EME 2 for extended periods of time then the quality plan must contain the details of this and evidence to support that this is not detrimental to the performance of the EME 2.
(c) Means taken to ensure that the EME 2 mix is delivered to the site without significant temperature losses.

8.6 Compaction

The quality plan shall specify the compaction plant and the rolling pattern that will be used. If a construction trial has been completed, then the rolling pattern will be based on the results of the trial.

This section shall include the onsite mix delivery temperatures and the associated rejection temperatures.

9 PLACING

9.1 General

The EME 2 paving shall be constructed in conformity with the lines, grades and typical cross-sections shown on the plans.

Where the construction of the layer or existing surface on which the paving is to be laid is not part of the contract, the road will be handed over in a condition ready to be prepared for paving, unless specified otherwise in the job specification. The Engineer will define the date of handover after consideration of the Contractor's proposed timing and sequence of operations. From the date of handover, the work necessary to retain or reinstate the surface shall be at the Contractor's expense.

When a correction layer is not specified, depressions and other irregularities shall be patched or corrected in a manner as directed by the Engineer. All fatty and unsuitable patches, excess crack or joint filler, and all surplus bituminous material shall be removed from the area to be paved. Blotting of surplus bituminous material with sand or stone will not be permitted.

The surface on which the paving is to be laid shall be free from standing water, and any loose material, dust, clay or foreign matter shall be removed by sweeping.

9.2 Thickness

The thickness of each EME 2 lift will normally be between 70mm and 130mm depending on the nominal maximum aggregate size. The pavement designer shall determine the minimum total EME 2 thickness.

9.3 Surface Pre-Treatment

9.3.1 Tack Coating

Tack coating shall be specified in the schedule of job details.

Tack coat shall be applied to the cleaned surface prior to placing EME 2. Where possible, tack coats shall be applied using a distributor. The use of a hand lance shall be minimised to ensure an even application of the tack coat.

Tack coat shall consist of bituminous emulsion. 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 should be applied to provide a uniform application rate of residual binder of between 0.2 and 0.6 L/m², depending on the texture and absorption of the substrate. Care must be taken to ensure application rates do not create excess binder on the substrate which could contribute to flushing of the finished EME 2.

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

Where EME 2 is to be spread over clean, freshly placed asphalt, the Engineer can direct the Contractor to omit the tack coat.

9.3.2 Chip Seal

If required under the EME 2, a chip seal shall be specified in the Schedule of Job Details. If a chip seal is placed under the EME 2 asphalt a tack coat is not necessary.

A chip seal can be applied to surfaces that require additional waterproofing and/or to provide a good friction bond between the EME 2 and the layer below. Unless otherwise directed, the chip seal shall be designed as a chip seal using recognised design algorithms such as in *Chipsealing in New Zealand*. They should consist of at least 1.0L/m² of residual binder and covered with a single layer of sealing chip, normally NZTA M06 Grade 4. Anti-stripping agents (adhesion agents) compatible with the sealing chip shall be included in the chip seal binder.

The use of volatile diluents in chip seal binders, such as kerosene, can cause mixes to flush. Seal binders must be carefully chosen to minimise this risk.

9.3.3 Blinding

It is recommended to spread a blinding layer of fine chip or a very thin layer of lean asphalt mix over tack coat applied to new granular base course to prevent pickup of the binder by construction traffic. The blinding material shall be sparingly spread so that the EME 2 bond to the tack coat is not compromised.

9.4 Protection of Services

The Contractor shall prevent tack coat, binder, aggregate, EME 2 or other material used on the work from entering, adhering to or obstructing gratings, hydrants, valve boxes, inspection pit covers, kerbs and other road fixtures.

9.5 Spreading and Trimming

9.5.1 General

Paving shall be carried out with the prior agreement of the Engineer for the method of construction to be used. The Contractor shall set out true line markings to be closely followed by the paver in constructing longitudinal joints and edges. The Contractor shall supply the Engineer with a detailed paving plan to be followed by the paver in placing individual lanes. Self-propelled paving machines shall be used to place EME 2, except for areas where accessibility mean the use of a paver is impracticable.

9.5.2 Ambient Conditions for Placing

EME 2 shall not be placed when the pavement surface temperature is less than 5°C.

9.5.3 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.

9.5.4 Operational Requirements

The EME 2 mix shall be spread and struck off with a self-powered paving machine capable of spreading and finishing the mix true to line, grade and cross-section without the use of forms or side supports. The paving machine shall be capable of laying layers in thicknesses as specified, and it shall be equipped with a suitably controlled screed-heating device. The screed shall strike off the mix to the elevation and cross-section required and shall provide a smooth and uniform texture without segregation, tearing, shoving or gouging. Equipment which leaves tracks or indented areas which cannot be corrected in normal operation, or which produces flushing or other permanent blemishes or fails to produce a satisfactory surface, shall not be used. A fully trained and experienced operator shall be in direct charge of the paving machine.

If the delivery of material to the paving machine ceases for a time sufficient to allow the temperature of the unrolled portion of the freshly laid mix to drop below the minimum temperature in the quality plan then the paving machine shall be withdrawn and rolling of the mix completed. Paving shall be recommenced from a transverse joint, which is located in a fully compacted area. Where the paving is to be laid to conform to the level of an adjacent finished surface, the EME 2 mix shall be spread sufficiently high so that when compacted, the finished surface will be true and uniform across the joint.

The adjustment of the screed, tamping bars, feed screws, hopper feed, etc. shall be checked frequently to assure uniform spreading of the EME 2 to proper line and grade and adequate initial compaction. Segregation of materials shall not be permitted. If segregation occurs, the spreading operation shall be immediately suspended until the cause is determined and corrected. Any area of segregation, which is not corrected prior to rolling, shall subsequently be removed and replaced with material supplied and compacted to specification requirements by the Contractor at their own expense.

Any irregularities in horizontal alignment left by the paver shall be corrected by trimming directly behind the machine. Immediately after trimming, the edges of the layer shall be thoroughly compacted by tamping. Distortion of the pavement during this operation shall be avoided.

Paving machines shall be operated so that material does not accumulate and remain along the sides of the receiving hopper. Material, which accumulates and cools along the sides of the receiving hopper of the paving machine shall be removed from the work site.

In small areas where the use of mechanical finishing equipment is not practical, the EME 2 can be spread and finished by hand. Wood or steel forms, rigidly supported to assure correct grade and cross-section, can

be used. In such instances, measuring blocks and intermediate strips shall be used to aid in obtaining the required cross-section.

9.6 Joints

9.6.1 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 the EME 2 to cool and adversely affect placing.

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 shape requirements specified in clause 10.

9.6.2 Longitudinal Joints

Longitudinal joints shall be offset from layer to layer by not less than 150mm provided that no joint is placed directly below a trafficked wheel path.

The Contractor shall explicitly nominate and control joint compaction techniques and temperature in the quality plan.

9.6.3 Transverse Joints

Transverse joints shall be offset from layer to layer by not less than 2m in adjoining paver runs.

9.7 Thickness Requirements

The thickness of the EME 2 layer shall be determined on a lot by lot basis. A pavement lot shall be an essentially homogeneous section of work completed within a shift of production, unless otherwise specified in the contract specification.

Non-compliant or unsatisfactory work shall be repaired, replaced or corrected by the Contractor at their own expense.

The cutting of test holes to check the depth of paving, the refilling with acceptable material, and proper compaction of this material shall be done by and at the expense of the Contractor.

Where a minimum thickness is specified by the contract, the lower characteristic value for the set of core specimens for the lot shall not be less than the specified minimum thickness. Calculate the Lower Characteristic Value for the thickness, as follows:

(a) Calculate the mean thickness for the set of cores;
(b) Calculate the sample standard deviation (s) for the thickness for the set of cores;
(c) Determine the Acceptance Constant (k) using the number of core specimens from Table 9.1;
(d) Calculate the Lower Characteristic Value (LCV), rounded to the nearest whole number, for the core thicknesses:

$$LCV = mean - (k \times s)$$

9.8 Compaction

The EME 2 shall be uniformly compacted to the standards specified in clause 9.8.1 as soon as it has cooled sufficiently to support the compaction equipment without undue displacement.

Compliance testing of the EME 2 shall be undertaken on a lot-by-lot basis by testing of core specimens. A pavement lot shall be an essentially homogeneous section of work completed within a shift of production, unless otherwise specified in the contract specification.

Specific gravity (relative density) and air voids testing for core specimens shall not be performed on lots of less than 30 tonnes.

All core holes shall be repaired by an appropriate method that is compatible with the pavement from which the cores have been taken. Sampling rates can be reduced with the agreement of the Engineer. Where the operators of the coring equipment are not accredited then they shall be supervised by a person accredited for the appropriate test.

For mixes with a nominal maximum aggregate size 14mm or less cores shall be 100mm nominal diameter or greater. For mixes coarser than 14mm cores shall be nominally 150mm diameter.

Core specimens may be trimmed when they have substrate materials adhering to their base. The depth of the EME 2 layer shall be measured prior to trimming. It is recommended that all cores are photographed prior to trimming. The photograph should include a scale rule.

The air voids of the core shall be determined in accordance with the requirements of ASTM D3203 except that ASTM D2726 shall always be used to determine the specimen bulk specific gravity and density. All core specimens sampled from a lot shall be used for the determination of compliance with this specification. Refer to M32 Notes.

For the determination of compliance, the maximum theoretical specific gravity (MTSG) used in the above calculation, in order of preference, can be taken as:

(a) The average of all samples taken from the production of that lot of EME 2 mix, or if there is insufficient EME 2 produced to require an MTSG test;
(b) The average of the last three MTSG test results provided each result is within acceptable limits (i.e. no outliers), or;
(c) The MTSG as measured by testing the broken down core specimens.

The testing of cores shall be commenced within 24 hours of their being cut from the pavement.

As an alternative to taking cores, nuclear methods of density measurement may be accepted at the discretion of the Engineer provided that the Contractor can justify the method with statistically validated comparative test data on the mix being produced. If nuclear methods are to be used, a fully detailed testing plan must be submitted to the Engineer for agreement. The thickness used as an input to the density determination shall be the specified thickness for the layer.

9.8.1 Mat Density

Where the nominal thickness is sufficient, cores shall be cut from the pavement at a rate of one core for every 300 m² with a minimum of eight cores representing each lot. A pavement lot shall be an essentially homogeneous section of work completed within a shift of production, unless otherwise specified in the contract specification. The lot shall be divided into an appropriate number of approximately equal sub-lots and a core shall be taken randomly within each sub-lot. The number of sublots shall be calculated from the lot area in m²/300 with a minimum of 8. The Engineer or his delegate shall use a random method for locating each core position, such as ASTM D5361 or a similar process.

The lot shall be deemed acceptable in terms of density if the characteristic value for air voids for the mat are between the air voids value approved in the EME 2 asphalt mix design plus the offset values in Table 9.2 (i.e. mix design air voids value +3, -2.

Note that mat core testing may not be appropriate for smaller jobs, or for exception cases noted in clause 9.8 above.

9.8.2 Joint Density

Where the nominal thickness is sufficient, cores shall be taken from randomly located distances along joints at the rate of one per 100 m of joint with a minimum of three representing each lot. The cores shall abut or span the joint line. The Engineer or his delegate shall use a random method for locating each core position, such as ASTM D5361 or a similar process.

The relevant sub-lot shall be deemed acceptable in terms of density if the characteristic value for air voids for the joint are between the air voids value approved in the EME 2 asphalt mix design plus the offset values in Table 9.2 (i.e. mix design air voids value +5, -2).

Note that joint core testing may not be appropriate for smaller jobs, or for exception cases noted in clause 9.8 above.

9.8.3 Density Requirements

The upper and lower characteristic values for the core air voids are calculated as follows:

(a) Calculate the mean air voids for the set of cores;
(b) Calculate the sample standard deviation (s) for the air voids for the set of cores;
(c) Determine the Acceptance Constant (k) using the number of core specimens from Table 9.1;
(d) Calculate the Upper (UCV) and Lower Characteristic Value (LCV) for the core air voids:

$$UCV = mean + (k \times s)$$

$$LCV = mean - (k \times s)$$

Table 9.1 Acceptance Constants

Number of Tests or Measurements	Acceptance Constant (k)
2	0.403
3	0.535
4	0.617
5	0.675
6	0.719
7	0.755
8	0.783
9	0.808
10	0.828
11	0.847
12	0.863
13	0.877
14	0.890
15	0.901

Compliance limits for the upper and lower characteristic values for air voids shall be calculated by adding the offset values of Table 9.2 to the mix design air voids established during the mix design process. Upper and Lower characteristic values for air voids shall fall within these limits.

Table 9.2 Limits for Characteristic Values of In-situ Air Voids

Core Locations	Maximum Characteristic Offset Value (%)	Minimum Characteristic Offset Value (%)
Mat Cores	3	-2
Joint Cores	5	-2

10 FINISHED PAVEMENT PROPERTIES

10.1 Level

The level at the top of each layer of EME 2 shall not be less than or more than 10mm higher than the specified level.

10.2 Alignment

The horizontal location of any point on the pavement shall not vary by more than ± 50mm from the corresponding points shown on the documents, except where alignment with an existing pavement structure is necessary, when the new work shall be joined to the existing work or structure in a smooth manner.

10.3 Thickness

Where confirmation of EME 2 thickness is required, it shall be determined by coring to a recognised random sampling plan.

The thickness of each layer of EME 2 and other asphalt materials in the pavement shall comply with the thickness requirements of clause 9.7.

11 MEASUREMENT AND PAYMENT

The basis for payment shall be included in the contract specification.

11.1 Non-Complying Materials

In the event that the material supplied is not within the tolerances and standards defined for manufacture or placing of EME 2, the Engineer can direct:

(a) The removal of non-complying material; or,
(b) That the reduced service life arising from the non-complying material is offset by reducing payment for the non-complying material; or,
(c) With the consent of the Contractor, any other remedial treatment that is expected to provide the required level of service.

The basis for payment shall be included in the contract specification.

12 SCHEDULE OF JOB DETAILS

The following items shall be considered and scheduled in the contract specific job details:

(a) Location number (for more than one site).
(b) Length of contract.
(c) Width of paving.
(d) Layer depth.
(e) Layer depth nominal or minimum.
(f) Residual application rates for tack coat.
(g) If required, material for any correction layer/blinding coat.
(h) Residual application rate for correction layer tack coat.
(i) Construction trial if required.

13 REVISION REGISTER

Version	Date	Replaces	Changes
Draft v5.0	October 2021	New document	Review by EME 2 working group
Final draft	October 2021	Draft v5.0	Editorial tidy-up
Pilot draft	November 2021	Draft v5.1	Minor editorial amendments.
M32: 2021	February 2022	Pilot draft	Minor editorial amendments