04010 Asphalt Mix

Index

Tables, Equations and Figures

***Bold text denotes a change in this version (February 2024)**

04010-1 General

1.1 Description

This section specifies requirements for labour, machinery, plant, equipment and materials required to produce hot mix asphalt concrete.

1.2 Related Sections

Section 04015 Asphalt Paving.
Section 04020 Reclaimed Asphalt Pavement

1.3 Definitions

1.3.1 Bitumen

A Class of black or dark coloured (solid, semisolid, or viscous) cementitious substance, natural or manufactured, composed principally of high molecular weight hydrocarbons, of which asphalts, tars, pitches, and asphaltites are typical.

1.3.2 Asphalt

A dark brown to black cementitious material in which the predominating constituents are bitumens which occur in nature or are obtained in petroleum processing.

1.3.3 Asphalt Cement

The bituminous material that is used to bind the asphalt mix aggregate. A fluxed or unfluxed asphalt specifically prepared as to quality and consistency for direct use in the manufacture of bituminous pavements and having a penetration at 25°C (77°F) of between 5 and 300, under a load of 100 g applied for 5 seconds.

1.3.4 Asphalt Aggregate

The individual crushed and processed aggregate fractions before combining to produce the asphalt mix aggregate.

1.3.5 Asphalt Mix Aggregate

The mix after combining the asphalt aggregate fractions including filler or blending sand to produce the specified mix gradation.

1.3.6 Asphalt Mix

The mix produced by combining asphalt cement with the asphalt mix aggregate.

1.3.7 Performance Graded (PG) Asphalt Binders

Asphalt binder grade designation used in Superpave. It is based on the binder's mechanical performance at critical temperatures and aging conditions.

1.3.8 Polymer Modified Asphalt

Conventional asphalt cement to which one or more polymer compounds have been added to improve resistance to deformation at high pavement temperatures and often cracking resistance at low temperatures.

1.3.9 Reclaimed Asphalt Pavement (RAP)

Asphalt millings or processed asphalt pavement removals, handled and characterized for RAP to be incorporated into asphalt mix.

1.3.10 Top Lift

The asphalt concrete wearing course.

1.3.11 Bottom Lift

All asphalt concrete courses below the Top lift.

1.3.12 Job Mix Formula

Establishes the target combined aggregate gradation, plant settings, approved asphalt cement content to be used for production of the asphalt mix, and the associated production tolerances, based on the submitted asphalt mix design and the results of the plant trials.

1.4 Mix Design Submittals

Contractors and Suppliers must submit a formal Mix Design, carried out by a certified laboratory prior to any hot mix asphalt (HMA) being placed. Marshall Mix designs are to be completed in accordance with the latest edition of the Asphalt Institute Manual Series No. 2 (MS-2), ASTM D6927 and AASHTO T-245 unless otherwise modified by City of Saskatoon requirements.

Any change in Supplier or materials will warrant the submission of a new mix design.

Mix design submissions shall contain, as a minimum:

- Asphalt cement data;
  - Name of Supplier and source(s) of the base asphalt cement(s)
  - Type and source(s) of additive(s)
  - Current laboratory test results of the asphalt cement
  - Mixing and compaction temperature, as determined by the asphalt cement's temperature-viscosity curve, or as recommended by the asphalt cement supplier;
- Aggregate data;
  - Source(s) of aggregates
  - Los Angeles Abrasion test results
  - Sand Equivalency results
  - Organic Content
  - Crush Count
  - Manufactured Fines
  - Individual Aggregate Gradations
- Reclaimed Asphalt Pavement (RAP) data, where RAP is included in the mix:
  - Source of the RAP
  - Asphalt Cement content of the RAP
  - Asphalt Cement contribution from the RAP
  - All RAP aggregate gradations for each RAP product
  - Specific gravity of the combined aggregates (when applicable)
  - RAP Rheology test results
- Asphalt Mix data;
  - Aggregate blend proportions
  - Combined aggregate gradation and bulk specific gravity

  - Asphalt cement absorption of the combined aggregates
  - Anti-stripping agent supplier, product name, application rate, and test results
- A minimum of five individual and separate asphalt cement contents (separated by a minimum of 0.5% AC content) must be used in the mix design;
- The following individual mix property results to be plotted;
  - Maximum Theoretical Density
  - Marshall Stability
  - Marshall Flow
  - Air Voids
  - Voids in Mineral Aggregate
  - Voids Filled with Asphalt
  - Film Thickness
- The Asphalt Mix Design & Job Mix Formula (JMF) Submission Summary sheet, as provided by the Engineer

1.4.1 Job Mix Formula (JMF)

On an annual basis, the Contractor shall submit a mix design and Job Mix Formula (JMF) for each type of hot mix to be supplied. The Contractor will only supply hot mix for which the Engineer has approved the JMF.

All asphalt mix shall be supplied to the approved job mix formula within the range of tolerances specified. Where tolerances are not specified, the values stated under this section shall be considered absolute, minimums, maximums or allowable ranges. Unless otherwise stated specification limits are based on single tests and include sampling, testing, and process variance.

Tolerances stated in this section and in Section 04015 shall apply to all asphalt concrete mix types unless otherwise specified.

The job mix formula, as originally established, shall remain in effect until modified in writing and approved by the Engineer. Should a change of aggregate(s) be made, or when unsatisfactory results or other conditions make it necessary, the Contractor shall submit a new mix design for approval.

04010-2 Materials

2.1 Asphalt Cement

All asphalt cements shall be prepared from petroleum oils. They shall be free from water and other impurities and shall not foam when heated to 175°C.

2.1.1 150-200A Asphalt Cement

150-200A Asphalt Cement shall conform to requirements listed in Table 1, Table 2 and Figure 1

Table 1: 150-200A Asphalt Cement Grade Requirements

Test Characteristics	**ASTM Test Method**	**Requirement**
Absolute Viscosity, 60°C, Pa·s	D2171	Viscosity and Penetration must fall within the area bound by area A-B-C-D-A in Figure 1 with coordinates as per Table 2
Penetration @ 25°C,100g 5s	D5	
Ductility, 15°C, cm (min)	D113	-
Ductility, 25°C, cm (max)	D113	100
Flash Point (COC),°C	D92	205
Solubility in Trichloroethylene min %	D2042	99.5
Thin Film Oven Test Weight Loss, Maximum %	D1754	1.0
Penetration at 25°C of minimum % or original	D5	50
Viscosity @60°C of residue Maximum % of original	D2171	-

Table 2: 150-200A AC Viscosity and Penetration Coordinates

Asphalt Cement Grade	Point	Absolute Viscosity	Pen
150-200A	A	155	150
	B	78	150
	C	50	200
	D	92	200

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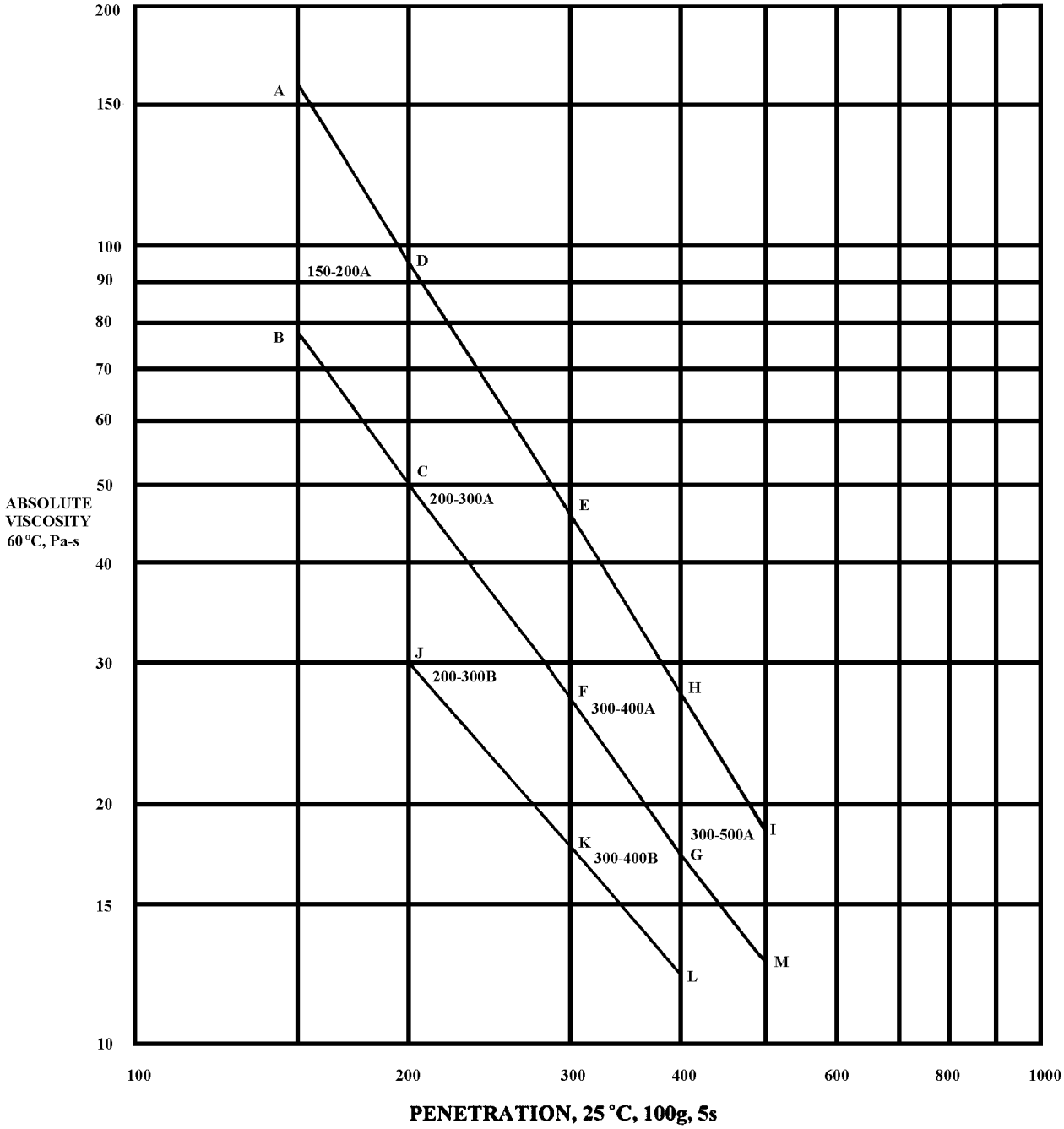
Figure 1: Asphalt Cement Viscosity and Penetration Requirements



2.1.2 PG 64-37 Asphalt Cement

The polymer modified asphalt cement shall be performance graded as determined by the current edition of AASHTO M320. Polymer modified asphalt cement shall meet or exceed the performance grade PG64-37, unless otherwise specified.

2.2 Asphalt Mix Aggregate

2.2.1 Asphalt Mix type Gradation

Asphalt mix aggregate shall meet the gradation requirements stated in Table 2, when tested to ASTM designations C-136 and C-117.

Table 3: Gradation for Asphalt Mix Aggregate

Sieve Designation	Asphalt mix type					
	1	**2**	**3**	**9**	**4**	**5 (SUTO)**
20.0 mm	100	-	-	-	-	-
16.0 mm	98-100	-	-	-	-	-
12.5 mm	82-89	100	100	100	-	-
9.0 mm	67-78	76-89	80-89	98-100	-	100
5.0 mm	49-59	50-60	59-69	85-95	100	90-100
2.0 mm	32-54	30-48	36-56	49-59	45-65	52-72
900 μm	22-42	19-38	24-41	32-42	22-44	35-55
400 μm	12-24	10-26	11-29	15-26	12-28	22-37
160 μm	3-10	3-10	3-12	6-15	6-15	10-21
71 μm	2-5	2-5	2-6	3-7	4-10	5-15

Percent Passing by Weight

2.2.2 Fines Composition

Asphalt mix aggregate, retained on the 5.0 mm plus sieves, shall be composed of fragments of durable rock and shall not contain more than 2% by weight of deleterious materials such as shale, ironstone, and coal. The maximum permissible organic content of the material passing the 5.0 mm sieve is 1.0%.

2.2.3 Physical Properties

Physical properties for aggregate shall meet the following requirements:

Table 4: Physical Properties for Asphalt Mix Aggregate

		Asphalt mix type	
Requirement	**Test Designation**	**1,9, & 5 (SUTO)**	**2, 3 & 4**
Sand Equivalence	ASTM D2419	45 min.	45 min.
Los Angeles Abrasion (% loss)	ASTM C131	30 max.	35 max.
Organic Content (% Passing 5.0 mm)		1.0 max.	1.0 max
Crush Count ([1]) (% Retained 5.0 mm Sieve)		80 min. 2 faces	70 min. 1 face
Manufactured Fines ([2]) (% Passing 5.0 mm Sieve)		70 min.	-

Notes:

1. Crush Count is the percentage of the crushed aggregate retained on the 5.0 mm plus sieves having either 1 or more fractured faces or 2 or more fractured faces, created by the crushing operation.

2. Manufactured fines are the percentage by mass of crusher run manufactured sand passing the 5mm sieve. For mixes incorporating RAP, 50% of the RAP passing the 5.0 mm sieve shall be considered manufactured sand.

3. Asphalt mix aggregate shall meet the gradation requirements stated in Table 2, when tested to ASTM designations C-136 and C-117.

2.3 Reclaimed Asphalt pavement (RAP)

The Contractor shall follow the best practices for obtaining, managing, sampling and testing RAP, as stated in Section 04020.

For the purpose of the Asphalt Mix design, the maximum allowable binder contribution from RAP for top and bottom lifts are as follows:

- Top lifts with PMA: 10%
- Top lifts without PMA: 15%
- All bottom lifts: 20%

The methodology used to determine the percent allowable RAP is as follows:

$$\%Allowable\ RAP = \frac{(\%\ Binder\ Contribution)(\%\ AC_{mix})}{(\%\ AC_{Rap})}$$

Equation 1: Percent Allowable Reclaimed Asphalt Pavement

Where:

- % Binder Contribution = selected to a maximum value specified above
- $\%AC_{mix}$ = target asphalt content of the selected mix type (% mass by total mix),
- $\%AC_{Rap}$ = asphalt content of the RAP, as determined by laboratory testing (% mass by total mix), and
- % Allowable RAP = the maximum RAP addition rate (% mass of total mix).

Should a change in the source or addition rate of RAP be made after the mix design has been approved, a new mix design and/or job mix formula shall be submitted to the City of Saskatoon Representative.

2.4 Asphalt Concrete Mix

Asphalt mix shall consist of a homogeneous mixture of asphalt mix aggregate, RAP, and asphalt cement mixed in a central plant.

2.4.1 Minimum Asphalt Cement Content

The minimum asphalt content by dry mass of aggregate, inclusive of the virgin asphalt cement and the asphalt cement contributed by the RAP, are as follows:

- 5.0% for Type 1 mixes
- 5.3% for Type 2 mixes
- 5.7% for Type 3 mixes
- 6.5% for Type 9 and Type 4 mixes
- 6.3% for Type 9P mixes
- 7.0% for Type 5 mixes (SUTO)

2.4.2 Anti Stripping Agent

Anti stripping agent, if required, shall be added to achieve a stripping potential of less than five percent (5%) as determined by the Saskatchewan Ministry of Highways and Infrastructure Stripping Potential Test STP 204-15. The Contractor shall provide test results identifying the type and amount of anti-stripping agent required to meet this requirement. The contractor shall provide the brand name and technical literature of the product to be used. The cost of the anti-stripping agent, if required shall be included in the unit prices under the contract.

2.4.3 Physical Properties

Physical properties for the mix shall meet the following requirements at the design asphalt content and gradation:

Table 5: Physical Properties for Asphalt Mix

	Asphalt mix type							
Property	**1P**	**1**	**2P**	**2**	**3 & 4**	**9P**	**9**	**5 (SUTO)**
Asphalt Grade	**PG 64-37**	**150 / 200A**	**PG 64-37**	**150 / 200A**	**150 / 200A**	**PG 64-37**	**150 / 200A**	**150 / 200A**
Marshall (blows per face)	75	75	50	50	50	75	50	50
Marshall Stability (KN) at 60°C min [1]	14	11	11	8	6	11	8	9
Retained Stability (%) (minimum)	75	75	75	75	75	75	75	75
Marshall Flow Index (mm) [1]	2-5	2-4	2-5	2-4	2-4	2-5	2-4	2-4
Air Voids in Mixture [2]	3.5-5.5	3.5-5.5	3-5	3-5	2-4	3-5	3-5	2-5
Voids filled with Asphalt (%) [2]	67-75	67-75	70-80	70-80	75-85	75-85	75-85	75-85
Min. Film Thickness (µm)	7.5	7.5	8.0	8.0	8.5	8.0	8.0	8.5

Notes:

1. Marshall Stability and Flow Index shall be determined according to ASTM Designation D6927 with the exception that briquettes shall be fan cooled as per Note 5 of D6927. A mechanical compactor, calibrated by a certified hand hammer, shall be used to prepare briquettes.

2. The percentage of air voids and percentage of voids filled with asphalt shall be determined in accordance with ASTM D3203 with ASTM C127 and C128.

2.5 Durable Pavement

The mixture must consist of porous asphalt coat design to provide approximately 20% void content, which is filled with a high strength proprietary grout.

2.5.1 Asphalt Coat Properties (Support Coat)

Particle Size Distribution

Sieve Size (mm)	Typical Percentage Passing
19	100
12.5	90
10	75
5	15
80um	3

Components

Coarse Aggregate 93%	High quality, 100% crushed
Asphalt Cement 4%	Conventional or PMA PG 58-28 or PG 64-34
Filler	Limestone
Fibres	Cellulose or Asphalt Shingle Modifier ASM (3%)
Mixing Temperature	130-160°C
Laying Temperature	120-150°C

2.5.2 Grout Properties

- **Strength typically in excess of 35 MPa at 28 days.**
- **Rapid strength gain (typically in excess of 15 MPa at 7 days), allowing for early trafficking of the finished material.**
- **Low viscosity of time of application, resulting in effective penetration of voids in the porous asphalt structure.**
- **A high strength grout is also available for high point load applications, with typical strenghs in excess of 30 MPa and 50 MPa at 7 and 28 days.**

2.5.3 Properties of the Composite

Typical 28 Day-Properties

- **NAT Indirect Tensile Stiffness Modulus: 6,000 MPa.**
- **Flexural Strength: 2.5 to 3.0 MPa.**
- **Freeze/Thaw: No Impact after 20 cyles.**
- **Skid Friction (British Pendulum Test): 80 (dry), 65 (wet).**
- **AASHTO 93 structural number of 0.47. This compares to an SN of 0.5 for concrete and 0.44 for asphalt.**

04010-3 Execution

3.1 General

All tools, machinery, plant and equipment used in handling materials and executing any part of the work shall be subject to the approval of the Engineer. All such equipment shall be maintained in efficient working order and where any of the machinery plant or equipment is found to be unsatisfactory; it shall be improved or replaced by the Contractor to the satisfaction of the Engineer.

3.2 Aggregates

Deliver and stockpile aggregates in accordance with the requirements of this section.

Segregate aggregate stockpiles by each aggregate fraction processed using substantial dividers or stockpile far enough apart to prevent intermixing.

Stockpile minimum of 50% of total aggregate fractions contracted before commencing trial mix designs. This quantity shall include aggregate stockpiled at both the processing site and asphalt plant site.

Stockpile at the plant site during production at least 15% of the total contracted amount for each size fraction processed.

When hauling into stockpiles after plant mixing has commenced do not deposit material against working face of stockpile.

Construct stockpiles in uniform lifts avoiding segregation by spillage of materials over the ends of previously placed lifts. Do not use stationary conveyors in stockpile construction.

Provide a previously stabilized stockpile base not less than 300 mm in depth to prevent contamination.

Aggregates from intermixed or contaminated stockpiles will be rejected and must be removed or disposed of as directed by the Engineer within 24 hours of rejection.

3.3 Asphalt Plant Operation

The asphalt plant and auxiliary equipment shall be such as to combine, dry and heat the asphalt mix aggregate, heat the asphalt cement and accurately proportion the asphalt cement and asphalt mix at a centrally located plant to the requirements of this section.

When combining aggregates during asphalt concrete mix production at no time shall two processed aggregate fractions share the same mechanical cold feed bin.

The asphalt plant shall meet the requirement of ASTM designation D995 for Bituminous Mixing Plant requirements.

The maximum planned storage time for any HMA shall be no more than 24 hours.

The maximum planned silo storage time for Type 1 and any polymer modified mixes shall be no more than 8 hours.

04010-4 Testing

The City of Saskatoon shall appoint an independent testing consultant to perform all tests for quality control of the mix to determine compliance with specification during production (process control), and quality assurance to determine acceptance and payment adjustments to material supplied and placed. This is not intended to relieve the contractor of the responsibility of maintaining their own quality control testing programs for the mix or preventing them from initiating shutdown of production for material that will be out of specification as determined from their own testing program.

Sampling for quality assurance will be done using a random sampling procedure as identified by the Engineer. Where there is continuous production uninterrupted by plant

shutdown due to quality control only the predetermined random sampling frequency will be used to determine payment adjustments to the unit bid price.

The quality assurance random sampling will also be the basis for quality control for generating control charts and determining plant shutdown. In addition to the quality assurance sampling the Engineer may also initiate supplementary tests independent of the quality assurance random sampling procedure to supplement the quality control tests for determining process control. These additional tests will not be used for payment adjustment factors unless it results in plant shutdown prior to the sampling for quality assurance in that specific lot of material. The supplementary test in this case will then be used for payment adjustment on that portion of the untested lot. If the supplementary test results in termination of production the contractor will be required to pay for the test.

The Contractor shall retain and pay an independent testing consultant to perform all materials certification tests and mix designs required in this section.

The Contractor, at their sole discretion, will secure samples of polymer modified asphalt cement from each 40-80 tonne shipment. These samples will be stored for a minimum period of six months and the contractor may test as many samples as they wish at their cost. The City will only accept test data from a certified testing lab. If it is discovered that a particular load of asphalt cement does not meet the PG grade the City will pay for the cost of the test and waive the mix adjustments that occur as a result of the lower grade of polymer modified asphalt cement.

End of Specification 04010