Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

CANADIAN STANDARDS AND RECOMMENDED PRACTICES

AIRPORT ENGINEERING

ASG-06

**PAVEMENT CONSTRUCTION:
MATERIALS AND TESTING**

Public Works and Government Services Canada
Real Property Services Branch
Architectural and Engineering Services
Engineering Division, Airport Engineering

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1.0 MANAGERIAL SUMMARY

1.1 SCOPE

This manual presents the current Public Works and Government Services Canada (PWGSC), standards and guidelines related to pavements at Canadian airports including; construction materials, specifications, mix design, and quality control testing procedures.

1.2 OBJECTIVE

This manual is designed as a reference for designers and specification writers involved with the design and construction of pavement structures at Canadian airports, and for the guidance of field and laboratory testing personnel responsible for the quality control and quality assurance of pavement construction projects.

1.3 EMPHASIS

Because of the unique operational environment under which airport pavements are constructed and required to perform, PWGSC requirements for construction materials, workmanship and construction quality control differ from those of most other agencies.

This manual is intended as a guide to ensure that these differences in requirements are recognized and implemented. Failure to follow these standards and guidelines without due consideration of the engineering implications could seriously reduce the life cycle cost-effectiveness of pavement facilities.

1.4 RESPONSIBILITIES

The Regional Center of Expertise (COE), PWGSC, Architectural and Engineering Services (A&ES) is responsible for ensuring that the standards contained in this manual are implemented on airport pavement construction projects.

PWGSC, Real Property Services Branch, A&ES, Engineering Division, Airport Engineering is responsible for maintaining and updating this manual on a continuing basis.

1.5 CANCELLATION

This document cancels and supersedes ASG - 06 (AK-68-23), Pavement Construction: Materials and Testing, dated September 1994.

2.0 MATERIALS SPECIFICATIONS

2.1 SUPPLY OF CEMENTS

2.1.1 GENERAL

Guideline i) When asphalt or Portland cement prices are volatile and subject to change throughout the duration of a contract, payment for supply of cement should be through a cash allowance.

2.1.2 ASPHALT CEMENT

Guideline i) Payment for supply of asphalt cement as a separate pay item should be based on direct measurements; e.g., bulk weights of deliveries, container volume/ count, storage tank measurements. Extractions are not sufficiently accurate and should not be used to calculate asphalt cement quantities.

Guideline ii) Supply of asphalt cement should be measured as a separate pay item on contracts where the estimated quantity of hot mix asphalt concrete exceeds 10,000 tonnes, on contracts in remote sites or on contracts where the cost of asphalt cement is high.

2.1.3 PORTLAND CEMENT

Guideline i) On contracts where the estimated quantity of Portland cement concrete exceeds 7,500 m^3, Portland cement shall be measured as a separate pay item.

2.2 STANDARD MATERIAL REQUIREMENTS

Standard i) The standard material requirements listed in Appendix A to G, shall be specified for all airfield pavement construction projects.

Guideline i) In preparing project specifications, the appropriate National Master Specification (NMS) sections should be edited to comply with these standard requirements.

Guideline ii) Modifications to the standard material requirements should be considered only where:

1) materials meeting these requirements are not available locally; and

2) it can be demonstrated that a satisfactory and cost-effective design can be obtained with the use of non-standard materials.

Guideline iii) Each use of non-standard materials should be fully documented, with a technical justification, cost analysis and a list of design changes.

Guideline iv) Whenever an industry standard (e.g., ASTM, CGSB, CSA) is specified, the date of the current issue of that standard should be specified. Industry standards quoted in this manual should be understood to be the current issue.

2.3 COMPACTION SPECIFICATIONS

Standard i) The standard compaction requirements listed in Appendix H, shall be specified for all airfield pavement construction projects.

Standard ii) Swelling Soils

All soils falling within the MH or CH soils classification shall be checked for swell potential in accordance with ASTM D1883.

Soils with high swell potential shall be studied to establish the relationship between swelling characteristics, density, and moulding/compacting moisture content.

Guideline i) Difficult Compaction Situations

Compaction requirements should be reduced when certain subgrade soils (e.g., silts, silty clays and sensitive clays) with high above optimum moisture content are encountered, and circumstances do not permit reasonable aeration procedures. Other actions which should be considered are to increase the depth of the sub-base layer or to stabilize the material using hydrated lime, Portland cement, fly ash or other suitable material.

2.4 LABORATORY DENSITY DETERMINATIONS

2.4.1 UNBOUND SOIL AND AGGREGATE LAYERS

Standard i) The laboratory density specified for each field sample shall be the corrected maximum dry density determined in accordance with ASTM D1557 and calculated using the following equation:

$$D = (F1 \times D1) + (0.9 \times D2 \times F2)$$

where:

D = corrected maximum dry density kg/m^3.

F1 = fraction (decimal) of total field sample passing the 4.75 mm sieve.

F2 = fraction (decimal) of total field sample retained on the 4.75 mm sieve. (equal to 1.00 - F1)

D1 = maximum dry density, kg/m^3, of material passing the 4.75 mm sieve in accordance with method A of ASTM D1557.

D2 = bulk density, kg/m^3, of material retained on the 4.75 mm sieve, equal to 1000 G where G is the bulk specific gravity (dry basis) of material when tested to ASTM C127.

Guideline i) Where, due to the large maximum size or free-draining properties of an unbound soil or aggregate, ASTM D1557 cannot be used to determine the laboratory density, one of the following alternative methods should be specified to determine the degree of compaction:

1) relative density as determined by ASTM D4253; or

2) the use of a field compaction trial using different compaction equipment, conditions, and sequences to determine the maximum practical level of compaction under construction conditions.

2.4.2 CEMENT-STABILIZED BASE

Standard i) The laboratory density specified shall be that determined in accordance with Method B of ASTM D558 using the compactive effort of ASTM D1557.

2.4.3 ASPHALT CONCRETE

Standard i) The laboratory density specified shall be that of Marshall briquettes moulded in accordance with ASTM D1559, using plant-mixed asphalt concrete samples and determined on a daily basis.

2.5 MIX DESIGNS

2.5.1 APPROVAL OF MIX DESIGNS

Standard i) Mix designs shall be submitted to the appropriate A&E Services Regional office for review and approval prior to beginning mix production.

Guideline i) Proposed field adjustments to approved mix designs should be submitted to the appropriate A&E Services Regional office for review and approval.

2.5.2 ASPHALT CONCRETE MIXES

Standard i) The Marshall method of mix design shall be used for design of hot mix asphalt concrete mixtures.

Standard ii) Asphalt concrete mixes shall be designed to meet the requirements of Appendix C, D, and E.

Standard iii) The Index of Retained Stability shall be determined by the test procedure given in Appendix L. The retained stability should be greater than 75%. An anti-stripping additive may be added to the mix design improve the retained stability.

Standard iv) The percentage asphalt content of the mix shall be determined based on the total mass of mix.

Guideline i) The job mix formula selected should use the optimum asphalt content as determined in accordance with Chapter 5 of MS-2, Mix Design Methods for Asphalt Concrete and other hot-mix types published by the Asphalt Institute.

Guideline ii) Void properties of asphalt mixes should be determined in accordance with the procedures in Chapter 4 of MS-2, Mix Design Methods for Asphalt Concrete and other hot-mix types published by the Asphalt Institute.

2.5.3 PORTLAND CEMENT CONCRETE MIXES

Standard i) Portland cement concrete mixes for pavements shall be designed to meet the requirements of Appendix F and G.

Standard ii) Admixtures other than air-entraining agents shall not be used unless a mix with satisfactory properties cannot otherwise be obtained. Calcium chloride and admixtures containing calcium chloride are not permitted.

Guideline i) Concrete mix design requirements should be specified in the manner stipulated in Table 11 of CAN/CSA A23.1.

The required mix proportions as detailed in Table 11 for Alternative 2 (owner responsible for mix design) should normally be specified for major projects or for isolated areas or projects on which the owner controls all raw material sources. Where Alternative 2 is specified, Portland cement should be paid for as a separate pay item even for smaller quantities than stated in 2.2.3 (i).

The required mix properties as detailed in Table 11 for Alternative 1 (contractor responsible for mix design) should normally be specified for small projects in built-up areas where the ready-mix concrete industry is well-established.

Where mix proportions are not known prior to tendering, approximate proportions based on experience should be specified with the provision that the engineer will establish final proportions prior to commencing production.

Guideline ii) For normal Portland cement concrete pavements, contract specifications should stipulate that the cement content be between 280 kg/m^3 to 310 kg/m^3, unless required to correct specific mix deficiencies. When designing high strength or special purpose pavements cement content should be selected to suit project requirements.

Guideline iii) Where the use of an admixture is approved in order to obtain certain mix characteristics for placing or finishing purposes, the contractor should bear the cost. Admixtures should not be approved as a means of decreasing the amount of cement required to meet concrete mix requirements.

2.5.4 MODIFICATION AND STABILIZATION OF SUBGRADE SOILS

Guideline i) The appropriate lime or cement content for the stabilization or modification of subgrade soils should be determined by laboratory or field investigation of the effects on the engineering properties of the soil and the cost effectiveness of such improvements.

2.5.5 CEMENT STABILIZED BASE COURSES

Standard i) Cement content for Cement Stabilized Base Courses shall be selected which will limit weight loss to under 14 percent when the material is subject to Wetting and Drying Tests (ASTM D559) and Freezing and Thawing Test (ASTM D560).

Standard ii) A minimum cement content of 5 percent by weight of dry aggregate shall be used, to allow for mix variations during construction.

Guideline i) Cement Stabilized Base Mixes should be designed using a series of laboratory trial mixes at varying cement contents.

Guideline ii) A cement content of 5 to 7 percent by weight of dry soil should be assumed for contract quantity estimating purposes.

2.5.6 SLURRY SEALS

Guideline i) The slurry seal mix design should be determined in accordance with ASTM D3910.

Guideline ii) The grade of emulsion used on slurry seals should be SS-1 or SS-1h, in accordance with CAN / CGSB 16.2.

Guideline iii) The emulsion content chosen should provide a mix with:

(1) low wear values;

(2) absence of segregation in the mix;

(3) no surface skinning or tackiness.

Guideline iv) The mix design test report should include the following:

(1) average wear value (WTAT loss) in grams per square metre for each quantity of emulsified asphalt;

(2) total amount of water added (percent based on mass of aggregate);

(3) any tendencies observed towards mix segregation during the preparation of test specimens;

(4) observations of texture, signs of surface skinning or tackiness in the specimen at the start of the test procedure; and

(5) the percentage of Portland cement or hydrated lime added.

2.5.7 RUBBERIZED COAL TAR PITCH EMULSION SLURRY SEALS

Guideline i) The procedures outlined in CGSB 37-GP-39M and CGSB 37-GP-40M should be followed in designing and applying Rubberized Coal Tar Pitch Emulsion (RCTPE) Slurry Seal as a jet fuel protective coating.

Guideline ii) Non coal tar based products are available for use as jet fuel protective coatings. Consult Airport Engineering, Ottawa regarding available products and their suitability.

3.0 MATERIALS TESTING

3.1 TESTING LABORATORY

Standard i) Section 01410, "Testing Laboratory Services" of the National Master Specifications (NMS) for construction shall be included in the specifications for all pavement construction projects.

Standard ii) Where the designated testing laboratory is not a Public Works and Government Services Canada facility, the field and headquarters lab facilities shall be inspected prior to the start of the project, to ensure that they are adequately equipped and maintained.

3.2 MATERIALS SAMPLING

Standard i) Sampling of materials for testing purposes shall be performed by the Engineer, at least as frequently as the minimum testing frequencies prescribed in Appendix I.

Standard ii) Samples shall be random and representative of lots of production units from which samples are extracted.

Standard iii) The date, time, location, person sampling and size of lot or production unit from which a sample is obtained shall be recorded.

3.3 AGGREGATE SOURCE APPROVAL

Standard i) Sources of aggregates proposed for use in a pavement construction project shall be tested for compliance with specification requirements prior to production.

Standard ii) Approval of proposed aggregate sources on the basis of these preliminary tests shall be tentative and conditional on the production of acceptable aggregate materials throughout the course of the work.

Standard iii) Proposed aggregates shall be tested for compliance with abrasion loss requirements.

Guideline i) Non-crushed samples should be crushed in the laboratory to approximately the size specified for the material to be produced.

Guideline ii) A minimum of three samples should be obtained and tested from each proposed source.

Guideline iii) Where applicable, proposed materials should be tested for:
- gradation;
- crushed content;
- Atterberg limits (liquid limit, plasticity index and plasticity limit);
- abrasion loss;
- soundness;
- sand equivalent;
- flat and elongated particles;
- lightweight particles in aggregate;
- absorption

Guideline iv) Additional abrasion and soundness tests should be performed if test results are marginal or should material changes be suspected from visual inspection during production.

Guideline v) Pre-qualification testing of proposed sources of aggregates prior to construction may be waived by the Engineer provided that:

(1) the same source of material has been used successfully in previous pavement construction projects;

(2) the source met specification requirements when tested previously;

(3) source approval and justification are provided in writing.

3.4 TRADE PRODUCTS

Standard i) Trade products shall be sampled in accordance with the minimum frequencies given in Appendix I.

Standard ii) A minimum of one sample of each trade product shall be tested for compliance with specified requirements, with the exception of air-entraining agents and concrete curing compounds.

Guideline i) Proposals for the use of trade products should be accompanied by a certificate from the supplier or manufacturer detailing conformance with the specified requirements.

Guideline ii) Where possible, samples of trade products should be taken for each batch or lot of material delivered to a project.

Guideline iii) Samples in excess of those tested should be stored for future testing in the event that construction problems are encountered with the materials. Provided no problems arise, samples should be discarded either after six months or according to Engineer's instructions.

3.5 QUALITY CONTROL TESTING

Standard i) Pavement construction materials shall be tested during construction for specification compliance in accordance with the minimum testing frequencies prescribed in Appendix J.

Guideline i) More frequent testing than that prescribed in Appendix J, should be carried out during the initial stages of a construction operation, when problems arise or when work or materials are of marginal quality.

Guideline ii) Testing should be performed to complement visual inspection in the quality control process, to verify visual observations. Isolated test results, which do not meet specified requirements may be accepted up to a limit in the order of 5 to 10 percent of the total number of tests, provided visual inspection indicates that the quality of workmanship and materials is acceptable.

Guideline iii) Testing should be carried out as soon as practical after samples are obtained, and test results should be provided to the project engineer at least daily, or immediately if they indicate workmanship or materials that do not meet specifications.

Guideline iv) Test results should be provided to the contractor after they are reviewed by the project engineer.

3.6 FIELD DENSITY TESTING

3.6.1 FREQUENCY OF TESTING

Standard i) Field density test shall be carried out in accordance with the minimum frequencies given in Appendix K.

3.6.2 SOIL AND AGGREGATE LAYERS

Standard i) One or more of the following methods shall be used to measure in-place densities and moisture of both bound and unbound soil and aggregate layers:

(1) ASTM D1556, "Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method";

(2) ASTM D2167, "Test Method for Density and Unit Weight of Soil In-Place by the Rubber Balloon Method";

(3) ASTM D2922, "Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Method (Shallow Depth)"; and

(4) ASTM D3017, "Test Method for Moisture Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)".

Standard ii) Nuclear gauge shall be calibrated and be correlated with tests carried out by ASTM D1556 or ASTM D2167.

Guideline i) The direct transmission method should be used to measure in-place density by Nuclear Methods with the probe extended to the full depth of the layer being measured.

Guideline ii) Particular attention should be paid to proper and frequent calibration of nuclear density gauges used for testing the compaction of soil, aggregate and cement stabilized layers.

Guideline iii) The field density of stabilized materials should be measured within 30 minutes (depending on ambient conditions) while the material is still in a plastic condition.

3.6.3 ASPHALT CONCRETE PAVEMENT

Standard i) The field density of compacted asphalt concrete shall be determined from the bulk density of 100 mm diameter core samples.

Standard ii) Nuclear gauge measurements should not be used for final acceptance.

Guideline i) Core samples should be representative of the entire pavement and should be taken randomly across the mat as well as along the longitudinal and transverse joints.

Guideline ii) Nuclear gauge measurements may be used to provide an indication of density during the lay down and compaction of asphalt and should be used to determine optimum rolling patterns during the initial compaction stage or from a test section if specified.

Guideline iii) Consult Airport Engineering, Ottawa prior to using the nuclear gauge as a compaction monitoring tool.

APPENDIX A

STANDARD REQUIREMENTS FOR TRADE PRODUCTS

Product	Specification
Asphalt Cement	CAN/CGSB-16.3
Cut Back Asphalt	CAN/CGSB-16.1
Anionic Emulsified Asphalt	CAN/CGSB-16.2
Cationic Emulsified Asphalt	CAN/CGSB-16.4
Coal Tar Pitch Emulsion	CGSB 37-GP-39M
Portland Cement	CAN/CSA-A5
Air-Entraining Admixture	ASTM C260
Concrete Admixtures	ASTM C494
Curing Compound (type 1-D or 2)	ASTM C309
Joint Sealants (Hot-applied)	ASTM D3405
Joint Sealants (JFR, Cold-applied)	CAN/CGSB-19.20
Joint Sealants (JFR, Hot-applied)	ASTM D3569
Joint Sealants (JFR, Silicone)	FAA Interim Specification Engineering Brief #36
Lime, Hydrated (Type "N")	ASTM C207
Mineral Filler	ASTM D242
Traffic Paint	CGSB 1-GP

APPENDIX B

STANDARD REQUIREMENTS FOR BASE AND SUB-BASE AGGREGATES (1)

Property	ASTM Test Method	Sub-base (2)	Base (3)	Base Levelling Material (4)	Cement Stabilized Base
Gradation (sieve/% passing)					
75 mm	C136	100			
50 mm	C136		100		
37.5 mm	C136		75-100		100
25 mm	C136			100	
19.0 mm	C136		50-75	75-100	75-100
9.5 mm	C136		40-65	50-75	
4.75 mm	C136		30-50	30-50	35-65
2.00 mm	C136				20-50
0.425 mm	C136	0-30	10-30	10-30	
0.300 mm	C136				10-30
0.150 mm	C136				0-10
0.075 mm	C117	0-8	3-8	3-8 (5)	
Crushed Content (%) min.					
50 to 37.5 mm			60		
37.5 to 19.0 mm			60	60	
19.0 to 4.75 mm			60	60	
Liquid Limit (%) max.	D4318	25	25	25	25
Plasticity Index (%) max.	D4318	6	6	6	6
Abrasion Loss (%) max.	C131	50	45	45	50
Soundness loss (%) max. Coarse aggregate (>4.75 mm) Fine aggregate (<4.75 mm)	C88 (6)				 12 16
Flat or Elongated Particles (%) max. (7)	D4791	15	15	15	15

Notes:
(1) Aggregates to be sound, hard, durable stone or gravel free from soft, thin, elongated or laminated particles, organic or other deleterious substances.
(2) Add additional gradation limits based on locally available aggregate sources, if required for project.
(3) For roads, gradation limits may be specified to meet Provincial standards or modified to suit locally available aggregate sources.
(4) Material to level surface depressions.
(5) For gravel surfaced runways, use 5-10 % passing, 0.075 mm sieve.
(6) Use magnesium sulphate in test method ASTM C88 for soundness loss and 5 immersion-drying cycles.
(7) Use dimensional ratio of 5 to 1 .

APPENDIX C

STANDARD REQUIREMENTS FOR ASPHALT CONCRETE AGGREGATES (1)

Property	ASTM Test Method	Hot Mixed		Sheet Asphalt	Mixed-in-Place Asphalt
		Lower Course	Surface Course		
Gradation (sieve/% passing)					
25.0	C136	100			100
12.5	C136	70-85	100		80-100
9.5	C136			100	70-90
4.75	C136	40-65	55-75	85-100	50-70
2.36	C136			80-95	35-50
2.00	C136	30-50	35-55		
1.18	C136			70-90	
0.6	C136			55-80	18-29
0.425	C136	15-30	15-30		
0.300	C136			30-60	
0.180	C136	5-20	5-20		
0.150	C136			10-35	
0.075	C117	3-8	3-8	4-14	4-10
Crushed content (%) min. 25.0 mm to 12.5 mm 12.5 mm to 4.75 mm		 60 60	 60	 60	 60 60
Abrasion Loss (%) max.	C131 (2)	30	25	25	25
Soundness Loss (%) max. Coarse Aggregate (> 4.75 mm) Fine Aggregate (< 4.75 mm)	C88 (3)	 12 16	 12 16	 12 16	
Sand Equivalent (%) max.	D2419	50	50	50	35
Lightweight Pieces (%) max.	C123	3	1.5	1.5	3
Liquid Limit (%) max.	D4318	25	25	25	25
Plasticity Index (%) max.	D4318	6	6	6	6
Absorption (%) max.	C127	2	2	2	2
Flat or Elongated Particles (%) max. (4)	D4791	10	10	10	10

Notes:
(1) Aggregates to be sound, hard, durable, crushed stone or gravel free from soft, thin, elongated or laminated particles, organic or other deleterious substances.
(2) In test method ASTM C131 for abrasion loss, use grading "B" for lower course and grading "C" for surface course aggregate.
(3) Use magnesium sulphate in test method ASTM C88 for soundness loss and 5 immersion-drying cycles.
(4) Use dimensional ratio of 5 to 1 .

APPENDIX D

STANDARD REQUIREMENTS FOR ASPHALT CEMENTS (1)(2)

Site Freezing Index (3) (degrees Celsius - days)	Penetration Grade	
	Runways, Taxiways and Roads	Aprons
< 500	80-100	80-100
500 - 1400	120-150	80-100
>1400	150-200	120-150

Notes:
(1) Asphalt Cements to CAN/CGSB-16.3-M90
(2) When specifying asphalt cement requirements, include the asphalt penetration, asphalt temperature susceptibility group and a reference to the Viscosity-Penetration chart to be used (either Kinematic Viscosity vs. Penetration or Absolute Viscosity vs. Penetration) in accordance with CAN/CGSB-16.3.
(3) For a site freezing index over 500, specify asphalt cement with high viscosity.

APPENDIX E

STANDARD REQUIREMENTS FOR ASPHALT CONCRETE MIXES

Property	Test Method	Asphalt Concrete		Sheet Asphalt
		Airfields	Roads	
Compactive effort on briquette specimens (blows per face)		50	75	75
Marshall Load (kN) min. For design aircraft tire pressure: < 0.35 MPa 0.35 to 1.40 MPa > 1.40 MPa	ASTM D1559	 5.0 7.0 9.0	5.5	3.25
Marshall Flow Index (mm) min. - max.	ASTM D1559	2-4	2-4	2-4.5
Air Voids (%) min. - max.	ASTM D3203	3-5	3-5	3-5
Voids in Mineral Aggregate (%) min. 9.5 mm max.-sized aggregate 12.5 mm max.-sized aggregate 25.0 mm max.-sized aggregate	MS-2 Chapter IV (Asphalt Institute)	 15 13	 15 13	 16
Marshall Immersion Index of Retained Stability (%) min.	Appendix L	75	75	

APPENDIX F

STANDARD REQUIREMENTS FOR PORTLAND CEMENT CONCRETE AGGREGATES (1)

Property	Test Method CAN/CSA-A23.2	Fine Aggregate (2)	Coarse Aggregate	
Gradation	2A	CAN/CSA-A23.1 Table 1	CAN/CSA-A23.1,Table 2 Nominal Sizes:	
			28-5 (3)	40-5 (4)
Crushed Content (%) max. (5)			50	50
Soundness Loss (%) max.	9A (6)	16	12	12
Organic Impurities	7A	Lighter than standard (7)		
Low Density Material (%) max.	4A (8)	0.5	0.5	0.5
Clay Lumps (%) max.	3A	1	0.25	0.25
Flat and Elongated Particles (%) max. (9)	13A		15	15
Abrasion (%) max.	16A		35	35

Notes:
(1) Ensure concrete aggregates and concrete mix are resistant to alkali-aggregate reactivity (AAR) in accordance with appendix B of CAN/CSA-A23.1
(2) Where crusher screenings are blended with sand, the screenings shall not exceed 25 percent by mass of the fine aggregate.
(3) Gradation for either crushed gravel or crushed rock.
(4) Alternative gradation for crushed rock.
(5) Crushed content to be determined on each coarse aggregate sieve size.
(6) Use magnesium sulphate for soundness loss and 5 immersion-drying cycles.
(7) If colour is darker than standard, perform test 8A to evaluate the effect of organic impurities on the strength of the mortar.
(8) Use heavy liquid of a specific gravity of 2.40 to separate light particles such as shale (specific gravity 2.35), coal, or Lignite (specific gravity 2.0).
(9) Use dimensional ratio of 5 to 1 .

APPENDIX G

STANDARD REQUIREMENTS FOR PORTLAND CEMENT CONCRETE MIXES (1)(2)(3)

Properties	Test Method CAN/CSA-A23.2	Values (4)
Cement content (5)		280 to 310 kg/m^3
28-day Strength Flexural-Average (min.) Standard Deviation (max.) or Splitting Tensile-Average (min.) Standard Deviation (max.)	 8C 13C	 4.0 MPa 9% of mean 2.8 MPa 9% of mean
Water/Cement Ratio (max.)		0.45
Slump	5C	12mm to 35 mm
Entrained-air Content	4C	5% ± 1%

Notes:
(1) Ensure concrete aggregates and concrete mix are resistant to alkali-aggregate reactivity (AAR) in accordance with appendix B of CAN/CSA-A23.1.
(2) Exposure class is normally C-2 in accordance with CAN/CSA-A23.1.
(3) Chemical and superplasticizing admixtures in accordance with CAN/CSA-A23.1.
(4) Values are for standard airport mix and should be adjusted to suit special project requirements.
(5) Specify Type 10 Portland Cement to CAN/CSA-A5, unless special characteristics are required, such as sulphate-resistance or high early strength.

APPENDIX H

STANDARD COMPACTION REQUIREMENTS

Layer	Material Type	Minimum % Compaction (1)
Graded Area (Common Fill)	cohesive soil non-cohesive soil	90 90
Pavement Embankment (Common Fill)	cohesive soil non-cohesive soil	90 95
Subgrade (2)(3)	cohesive soil non-cohesive soil lime modified	93 98 95
Sub-base	unbound	98
Base	unbound bound	100 97
Asphalt Concrete		98
Bedding		95
Filter/Subdrain		95

Notes: (1) Compaction is the ratio of field density to laboratory density expressed as a percentage.

(2) For cohesive soils, compaction of the top 150 mm of subgrade shall be specified. For non-cohesive soils, compaction of the top 300 mm of subgrade shall be specified.

For compaction purposes, non-cohesive soil is defined as:
(a) all soils that have less than 20 percent passing the 0.075 mm sieve; and
(b) soils having between 20 and 50 percent passing the 0.075 mm sieve, and having a liquid limit less than 25 and a plasticity index less than 6.

(3) For swelling soils, compaction of the top 150 mm of subgrade shall specify ASTM D698 standard proctor and compacting at 2-3 percent wet of optimum moisture content.

APPENDIX I

SAMPLING REQUIREMENTS FOR TRADE PRODUCTS (1)

Material	Samples Taken From	Sampling Frequency	Sample Container	Sample Size	Minimum Quantity Requiring Sampling
Asphalt Cement	tank car or truck	1 per week min. 2 per job	2 sealed cans	5 L/can	5 t
Cutback Asphalt	tank car, truck or drum	1 per delivery min. 2 per job	sealed can	10L	1000L
Emulsified Asphalt	tank car, truck or drum	1 per delivery min. 2 per job	plastic container	10L	1000L
Coal Tar Emulsion	tank car, truck or drum	2 per job	plastic container	10L	400L
Portland Cement	bulk, barrels, bags	1 per week min. 2 per job	poly bag	10 kg	4 t
Air-Entraining Agent	drums	2 per job	sealed can	5L	50L
Curing Compound	drums	2 per job	sealed can	5L	400L
Joint Sealant (Hot-applied)	drums or cakes	2 per job	poly bag	10 kg	250 kg
Joint Sealant (Cold-applied)	drums	2 per job	sealed cans	component proportions for 5L	400L
Hydrated Lime	tank car, truck or bag	2 per job	3 sealed cans	3 kg/can	5 t

Note: (1) Sample as soon as possible after delivery, or after containers have been opened for use. Sample containers are to be airtight.

APPENDIX J

MINIMUM QUALITY CONTROL TESTING REQUIREMENTS

Work Phase	Type of Testing	Minimum Testing Frequency (No. of Test per Unit)
Common Fill		
Placing	Moisture-density relationship	2 per material type
Subgrade		
Compaction	Moisture-density relationship	2 per material type
Sub-base		
Placing	Moisture-density relationship	2 per material type
	Gradation	1 per day
	Atterberg limits	1 per week
Base		
Stockpiling	Gradation and crushed count	2 per day
	Atterberg limits	1 per week
Placing	Moisture-density relationship	2 per material type
	Gradation and crushed count	2 per day
Asphalt Concrete		
Aggregate Stockpiling	Gradation and crushed count	2 per day per aggregate type
Mix Production	Dry bin aggregate gradation (1)	2 per day per aggregate type
	Cold Feed Gradation (2)	2 per day per aggregate type
	Plant Marshall Test (3)	2 per day per mix
Placing	Straight edge	1 per 100m^2
Portland Cement Concrete		
Aggregate Stockpiling	Gradation and crushed count	2 per day
Mix Production	Slump and air content	1 per 100 m^3
	Flexural or Splitting tensile	2 per day (4)
Placing	Straight edge	1 per 100m^2

Notes:
(1) For batch and continuous-mix plants.
(2) For drum mix plants.
(3) Each plant Marshall test to include a minimum of 3 briquettes tested for; bulk density, stability, flow, air voids and VMA and one mix sample tested for; extraction bitumen content, aggregate gradation and crushed content.
(4) Each flexural strength test to include 3 beams, or each splitting tensile strength test to include 3 cylinders.

APPENDIX K

MINIMUM FIELD DENSITY TESTING REQUIREMENTS

Work Phase	Minimum Testing Frequency (No. of Tests Per Unit) (1)
Common Fill	1 per 3 000 m^2/lift
Subgrade	1 per 3 000 m^2
Sub-base	1 per 3 000 m^2/lift
Base	1 per 3 000 m^2/lift
Asphalt Concrete	1 per 1 000 m^2/lift
Bedding or Backfill (2)(3)	1 per 20 m/lift

Note: (1) When using a nuclear gauge for the field testing of in-place soils, increase frequency of testing to 1 per 500 m^2/lift.
(2) When using a nuclear gauge for density testing in trenches, use special precautions to correct for "trench wall effects" as per nuclear gauge manufacturers instructions.
(3) Includes subdrain and pipe bedding and surround, manhole and catchbasin bases and trench backfill.

APPENDIX L

MARSHALL IMMERSION TEST

SCOPE

This test method is intended to measure the effect of Marshall stability resulting from the action of water on compacted bituminous mixtures containing penetration grade asphalt. A numerical index of retained stability is obtained by comparing the stability of specimens that have been immersed in water for a prescribed period of time to the stability of specimens determined in accordance with ASTM D1559.

APPARATUS

The following apparatus will be required:

(i) One of more water baths with automatic controls shall be provided for immersing the specimens. Baths normally used for the Marshall test are suitable for the tests described herein.

(ii) A balance and a water bath with suitable accessory equipment will be required for weighting the test specimens in air and in water in order to determine their densities.

(iii) A supply of flat transfer plates of glass or metal will be required. One of these plates will be kept under each of the specimens during the immersion period and during subsequent handling, except when weighing and testing, in order to prevent breakage or distortion of the specimen.

TEST SPECIMENS

At least eight standard Marshall specimens shall be prepared for each test. The specimens shall be prepared in accordance with the procedure outlined in ASTM D1559, using a compactive effort of 50 or 75 blows per face as per appendix E.

To determine the specific gravity of a test specimen:

(1) Obtain the weight of the specimen in air and in water. The latter should be done as rapidly as possible to minimize absorption.

(2) Calculate the specific gravity of each test specimen as follows:

$$\text{Specific gravity} = \frac{A}{A - B}$$

where

A = weight of specimen in air in grams;
B = weight of specimen in water in grams.

TEST PROCEDURE

Sort each set of eight test specimens into two groups of four specimens each so that the average specific gravity of the specimens in group 1 is essentially the same as that of group 2. Test the specimens in group 1 as outlined in ASTM D1559. Immerse the group 2 specimens in water for 24 hours at 60 degrees C, then test immediately for stability and flow.

Break open each test specimen after testing for reporting of visual observation of all surfaces including the failure face.

TEST REPORT

The resistance of the mixture to the detrimental effect of water shall be expressed as a percentage of the original stability retained after the immersion period. It is calculated as follows:

$$\text{Index of Retained Stability} = \frac{S2}{S1} \times 100$$

where

S1 = Marshall stability of group 1 (average);
S2 = Marshall stability of group 2 (average).

The test report shall include a record of the visual observations for all test specimens. Observations to include the extent of cracked or broken aggregate and an estimate of the degree of moisture damage, if any.

RELATED DOCUMENTS

RELATED PWGSC DOCUMENTS

ASG-20 Pavement Construction Methods and Inspection

ASG-28 Pavement Construction Record

OTHER RELATED DOCUMENTS

Annual Book of ASTM Standards. American Society for Testing and Materials. Philadelphia, Pa.

Canadian General Standards (CAN/CGSB). Canadian General Standards Board. Ottawa, Ontario

National Standards of Canada (CAN/CSA). Canadian Standards Association. Rexdale, Ontario

Canadian National Master Construction Specifications (NMS). Construction Specifications Canada. Toronto, Ontario

Mix Design Methods for Asphalt Cement and Other Hot-Mix Types (MS-2). Asphalt Institute. Lexington, Kentucky.

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