Appendix E – Aggregate Quality Test Specifications

Aggregate quality tests are performed by the Ministry of Transportation of Ontario (MTO) for the Ontario Geological Survey on sampled material. A brief description and the specification limits for each test are included in this appendix. Although a specific sample meets or does not meet the specification limits for a certain product, it may or may not be acceptable for that use based on field performance. Additional quality tests other than the tests listed in this appendix can be used to determine the suitability of an aggregate. Greater detail on the tests and aggregate specifications can be obtained from the MTO.

Absorption Capacity (LS-604): This test is related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate. This test is conducted in conjunction with the determination of the sample's relative density.

Accelerated Mortar Bar Expansion Test (LS-620): This is a rapid test for detecting alkali–silica reactive aggregates. It involves the crushing of the aggregate and the creation of standard mortar bars. For coarse and fine aggregates, suggested expansion limits of 0.10 to 0.15% are indicated for innocuous aggregates; greater than 0.10%, but less than 0.20%, indicates that it is unknown whether a potentially deleterious reaction will occur; and greater than 0.20% indicates that the aggregate is probably reactive and should not be used for Portland cement concrete. If the expansion limit exceeds 0.10% for coarse and fine aggregates, it is recommended that supplementary information be developed to confirm that the expansion is actually because of alkali reactivity. If confirmed deleteriously reactive, the material should not be used for Portland cement concrete unless corrective measures are undertaken such as the use of low- or reduced-alkali cement.

Aggregate Abrasion Value (AAV) (British Standard 812): The AAV is a measure of the resistance of aggregate to surface wear by abrasion using a standard silica sand. A low AAV (6 or less) implies good resistance to abrasion. An aggregate with good resistance to abrasion will usually give good macrotexture. This test is described in British Standard 812 (1975).

Bulk Relative Density (BRD) (ASTM C29): An aggregate with low relative density is lighter in weight than one with a high relative density. Low relative-density aggregates (less than about 2.5) are often non-durable for many aggregate uses.

Los Angeles Abrasion and Impact Test (LS-603 or ASTM C131): This test measures the resistance to abrasion and the impact strength of aggregate. This gives an idea of the breakdown that can be expected to occur when an aggregate is stockpiled, transported and placed. Values less than about 35% indicate potentially satisfactory performance for most concrete and asphalt uses. Values of more than 45% indicate that the aggregate may be susceptible to excessive breakdown during handling and placing. This test has been replaced by the micro-Deval abrasion test for coarse aggregate (see below), but, because of the large number of Los Angeles abrasion analyses that exist in historical MTO records, this test can still provide an indication of the aggregate quality.

Magnesium Sulphate Soundness Test (LS-606): This test is designed to simulate the action of freezing and thawing on aggregate. Those aggregates which are susceptible will usually break down and give high losses in this test. Values greater than about 12 to 15% indicate potential problems for concrete and asphalt coarse aggregate.

Micro-Deval Abrasion Test (LS-618 and LS-619): The micro-Deval abrasion test for fine aggregate is an accurate measure of the amount of hard, durable materials in sand-sized particles. This abrasion test is quick, cheap and more precise than the fine aggregate magnesium sulphate soundness test that suffers from a wide multi-laboratory variation. The magnesium sulphate soundness test is still considered an alternative test as indicated in many of the accompanying tables in this appendix. The micro-Deval abrasion test for coarse aggregate has replaced the Los Angeles abrasion and impact test.

Petrographic Examination (LS-609): Individual aggregate particles in a sample are divided into categories good, fair, poor and deleterious, based on their rock type (petrography) and knowledge of past field performance. A petrographic number (PN) is calculated. The higher the PN, the lower the quality of the aggregate.

Polished Stone Value (PSV) (British Standard 812): The PSV is a measure of the resistance of aggregate to the polishing action of a pneumatic tire under conditions similar to those occurring on the road surface. The actual relationship between skidding resistance and PSV varies depending on the type of road surface, age, amount of traffic and other factors. Nevertheless, an aggregate with a high PSV will generally provide higher skid resistance than one with a low PSV. This test is described in British Standard 812 (1975). Values less than 45 indicate marginal frictional properties, whereas values greater than 55 indicate excellent frictional properties (average value no less than 50).

Unconfined Freeze–Thaw Test (LS-614): This test is designed to identify aggregate material that may be susceptible to excessive damage caused by freeze–thaw cycles. Aggregates that give losses greater than about 6% have a high probability of causing "popouts" on concrete and asphalt surfaces.

MATERIAL SPECIFICATIONS FOR AGGREGATES: BASE AND SUBBASE PRODUCTS

Table E1. Physical property requirements for aggregates: base, subbase, select subgrade and backfill material.

MTO Test Number	Laboratory Test	Granular O	Granular A	Granular B (Type I and Type III)	Granular B (Type II)	Granular M	Select Subgrade Material
LS-614	Unconfined Freeze–Thaw Loss (% maximum)	15	–	–	–	–	–
LS-616 LS-709	Fine Aggregate Petrographic Requirement	*[Note 1]*					
LS-618	Micro-Deval Abrasion Loss, Coarse Aggregate (% maximum loss)	21	25	30 *[Note 2]*	30	25	30 *[Note 2]*
LS-619	Micro-Deval Abrasion Loss, Fine Aggregate (% maximum loss)	25	30	35	35	30	–
LS-630	Amount of Contamination	*[Note 3]*					
LS-631	Plastic Fines	None Permitted					
LS-704	Plasticity Index (maximum)	0	0	0	0	0	0

Note 1. For materials north of the French River and Mattawa River only: for materials with >5.0% passing the 75 µm sieve, the amount of mica retained on the 75 µm sieve (passing the 150 µm sieve) shall not exceed 10% of the material in that sieve fraction unless testing (LS-709) determines permeability values $>1.0 \times 10^{-4}$ cm/s and/or field experience show satisfactory performance (prior data demonstrating compliance with this requirement will be acceptable provided such testing has been done within the past 5 years and field performance has been satisfactory).

Note 2. The coarse aggregate micro-Deval abrasion loss test requirement will be waived if the material has more than 80% passing the 4.75 mm sieve.

Note 3. Granular A, B Type I, B Type III, or M may contain up to 15% by mass crushed glass and/or ceramic material. Granular A, O, B Type I, B Type III and M shall not contain more than 1.0% by mass of wood, clay brick, and/or gypsum, and/or gypsum wall board or plaster. Granular B Type II and SSM shall not contain more than 0.1% by mass of wood.

Greater detail, additional specifications and other aggregate product information can be obtained from the Ministry of Transportation. Details above are derived from MTO SP-110513 (August 2007).

MATERIAL SPECIFICATIONS FOR AGGREGATES: HOT MIX ASPHALT PRODUCTS

Table E2. Physical property requirements for coarse aggregate (surface course): SMA, Superpave™ 9.5, 12.5, 12.5 FC1 and 12.5 FC2.

MTO Test Number	Laboratory Test	Superpave 9.5, 12.5	Aggregate Type			
			Gravel	Quarried Rock (SMA, Superpave 12.5 FC1 and 12.5 FC2)		
			(Superpave 12.5 FC1 only)	Dolomitic Sandstone	Traprock, Diabase, Andesite	Meta-arkose, Metagabbro, Gneiss
LS-601	Wash Pass, 75 µm sieve (% maximum loss)	1.3 *[Note 4]*	1.0 *[Note 5]*	1.0 *[Note 5]*	1.0 *[Note 5]*	1.0 *[Note 5]*
LS-604	Absorption (% maximum)	2.0	1.0	1.0	1.0	1.0
LS-608	Flat and Elongated Particles (% maximum (4:1))	20	15	15	15	15
LS-609	Petrographic Number (HL) (maximum)	*[Note 6]*	120	145	120	145
LS-613	Insoluble Residue Retained, 75 µm sieve (% minimum)	–	–	45	–	–
LS-614	Unconfined Freeze–Thaw Loss (% maximum loss)	6 *[Note 7]*	6	7	6	6
LS-618	Micro-Deval Abrasion Loss (% maximum loss)	17	10	15	10	15
Alternative Requirement for LS-614						
LS-606	Magnesium Sulphate Soundness Loss (% maximum loss)	12	–	–	–	–

Note 4. When control charts (n >20) are used for LS-601, the average value shall not exceed the specification maximum (1.3%), with no single value greater than 1.7%. When quarried rock is used as a source of coarse aggregate, a maximum of 2.0% passing the 75 µm sieve shall be permitted. When control charts (n >20) are used from LS-601 for quarried rock, the average value shall not exceed the specification maximum (2.0%) with no single value greater than 2.4%.

Note 5. When control charts (n >20) are used for LS-601, the average value shall not exceed the specification maximum (1.0%), with no single value greater than 1.4%.

Note 6. For the locations listed below, Petrographic Number (HL) is replaced by the following Petrographic Examination requirements. When the coarse aggregate for use in a surface course mix is obtained from a gravel pit or quarry containing more than 40% carbonate rock type, e.g., limestone and dolostone, then blending with aggregate of non-carbonate rock type shall be required such as to increase the non-carbonate rock type content of the coarse aggregate to 60% minimum, as determined by LS-609. The method of blending shall be uniform and shall be subject to approval by the owner. In cases of dispute, LS-613 shall be used with a minimum of acid insoluble residue of 60%. When the aggregate for a surface course mix is obtained from a non-carbonate gravel or quarry source, blending with carbonate rock types shall not be permitted. This requirement is applicable to coarse aggregates used in surface course mixes in the area to the north and west of a boundary defined as follows: the north shore of Lake Superior, the north shore of the St. Mary's River, the south shore of St. Joseph Island, the north shore of Lake Huron easterly to the north and east shore of Georgian Bay (excluding Manitoulin Island), along the Severn River to Washago and a line easterly passing through Norland, Burnt River, Burleigh Falls, Madoc, and hence easterly along Highway 7 to Perth and northerly to Calabogie and easterly to Arnprior and the Ottawa River.

Note 7. For Superpave 12.5 only, the requirements will be waived by the owner when the aggregate meets the alternative requirements for LS-606.

Table E3. Physical property requirements for coarse aggregate (binder course): Superpave™ 9.5, 12.5, 19.0, 25.0 and 37.5.

MTO Test Number	Laboratory Test	Superpave 9.5, 12.5, 19.0, 25.0 and 37.5
LS-601	Wash Pass, 75 µm sieve (% maximum loss)	1.3 *[Note 8]*
LS-604	Absorption (% maximum)	2.0
LS-608	Flat and Elongated Particles (% maximum (4:1))	*
LS-614	Unconfined Freeze–Thaw Loss (% maximum loss) *[Note 9]*	15
LS-618	Micro-Deval Abrasion Loss (% maximum loss)	21
Alternative Requirement for LS-614		
LS-606	Magnesium Sulphate Soundness Loss (% maximum loss)	15

Note 8. When control charts (n >20) are used for LS-601, the average value shall not exceed the specification maximum (1.3%), with no single value greater than 1.7%. When quarried rock is used as a source of coarse aggregate, a maximum of 2.0% passing the 75 µm sieve shall be permitted. When control charts (n>20) are used for LS-601 for quarried rock, the average value shall not exceed the specification maximum (2.0%), with no single value greater than 2.4%.

Note 9. This requirement will be waived by the owner when the aggregate meets the requirements for LS-606.

* Designer fill-in, contact the MTO.

Table E4. Physical property requirements for fine aggregate: SMA, Superpave™ 9.5, 12.5, 12.5 FC1, 12.5 FC2, 19.0, 25.0 and 37.5.

MTO Test Number	Laboratory Test	SMA, Superpave 12.5 FC2	Superpave 12.5 FC1	Superpave 9.5, 12.5, 19.0, 25.0 and 37.5
LS-619	Micro-Deval Abrasion Loss (% maximum loss) *[Note 10]*	15	20	25
LS-704	Plasticity Index (maximum)	0	0	0

Note 10. Where the blending method has been selected for QC, the micro-Deval abrasion loss of each individual fine aggregate in the stockpile, prior to blending, shall not exceed 35%.

Greater detail, additional specifications and other aggregate product information can be obtained from the Ministry of Transportation. The above specifications are from MTO SP-110F12 (2007).

MATERIAL SPECIFICATIONS FOR AGGREGATES: CONCRETE PRODUCTS

Table E5. Physical property requirements for coarse aggregate.

MTO or CSA Test Number	Laboratory Test	Acceptance Requirements	
		Pavement	Structures, Sidewalk, Curb and Gutter, and Concrete Base
LS-601	Material finer than 75 µm sieve, by washing (% maximum loss) *[Note 11]* • for gravel • for crushed rock	 1.0 2.0	 1.0 2.0
LS-604 or CSA A23.2-12A	Absorption (% maximum)	2.0	2.0
LS-608	Flat and Elongated Particles (% maximum (4:1))	20	20
LS-609	Petrographic Number (Concrete) (maximum)	125	140
LS-614 or CSA A23.2-24A	Unconfined Freeze–Thaw Loss (% maximum loss) *[Note 12]*	6	6
LS-618 or CSA A23.2-29A	Micro-Deval Abrasion Loss (% maximum loss)	14	17
LS-620 or CSA A23.2-25A	Accelerated Mortar Bar Expansion (% maximum at 14 days) *[Note 13, Note 14]*	0.150 *[Note 15]*	0.150 *[Note 15]*
CSA A23.2-14A	Concrete Prism Expansion (% maximum at 1 year) *[Note 13, Note 16]*	0.040	0.040
CSA A23.2-26A	Potential Alkali–Carbonate Reactivity of Quarried Carbonate Rock *[Note 17]*	Chemical composition must plot in the nonexpansive field of a specific figure used with test	
Alternative Requirement for LS-614			
LS-606	Magnesium Sulphate Soundness Loss, 5 cycles (% maximum loss) *[Note 12]*	12	12

General Notes:

- Where a concrete surface is subject to vehicular traffic, the physical requirements for "Pavement" will apply to the aggregate used.
- For air-cooled blast-furnace slag aggregate, the allowable maximum value for micro-Deval shall be 21% for structures and pavements and the allowable maximum value for absorption will conform to the owner's requirements for slag aggregate.
- A coarse aggregate may be accepted or rejected by the owner based on the results of freeze–thaw testing of concrete or field performance.

Note 11. When control charts (n >20) are used for LS-601, the average value shall not exceed the specification maximum (1.3%), with no single value greater than 1.7%. When quarried rock is used as a source of coarse aggregate, a maximum of 2.0% passing the 75 µm sieve shall be permitted. When control charts (n >20) are used for LS-601 for quarried rock, the average value shall not exceed the specification maximum (2.0%), with no single value greater than 2.4%.

Note 12. The owner will waive the requirements for freeze–thaw loss when the aggregate meets the alternative magnesium sulphate soundness requirements, LS-606.

Note 13. The need to demonstrate compliance with this requirement will be waived by the Contract Administrator if the source is on the current Ministry of Transportation regional Aggregate Source List (ASL) for Structural Concrete Fine and Coarse Aggregates or the Aggregate Source List of Concrete Base/Pavement Coarse Aggregates. If the aggregate is potentially expansive due to alkali–carbonate reaction as determined by CSA A23.2-26A, the aggregate shall meet the requirements of CSA A23.2-14A, even though it may be shown as a coarse aggregate on the ASL for Structural Concrete Fine and Coarse Aggregates or the ASL for Concrete Base/Pavement Coarse Aggregates.

Note 14. An aggregate that fails to meet these requirements will be accepted by the Contract Administrator provided the requirements of CSA A23.2-14A are met.

Note 15. If the aggregate is a quarried sandstone, siltstone, granite or gneiss, the expansion shall be less than 0.080% after 14 days. For quarried aggregates of the Gull River, Bobcaygeon, Verulam and Lindsay formations, the expansion shall be less than 0.100% after 14 days.

Note 16. An aggregate needs to meet this requirement only if it fails the requirements of either CSA A23.2-25A or CSA A23.2-26A. The test data shall have been obtained within the past 18 months from aggregate from the same location within the source as that to be used in the work. If this test is conducted to show that an average deemed potentially expansive by CSA A23.2-26A does not exceed 0.040% after one year, then chemical analysis, CSA A23.2-26A, shall be provided to show that the aggregate intended for use has the same chemical composition as the material tested in CSA A23.2-14A.

Note 17. This requirement only applies to aggregate quarried from the Gull River and Bobcaygeon formations of southern and eastern Ontario. These dolomitic limestones crop out on the southern margin of the Canadian Shield from Midland to Kingston and in the Ottawa–St. Lawrence Lowlands near Cornwall.

Table E6. Physical property requirements for fine aggregate.

MTO or CSA Test Number	Laboratory Test	Acceptance Limits
LS-610	Organic Impurities, (organic plate number) *[Note 18]*	3
LS-619 or CSA A23.2-23A	Micro-Deval Abrasion Loss (% maximum loss)	20
LS-620 or CSA A23.2-25A	Accelerated Mortar Bar Expansion (% maximum at 14 days) *[Note 19, Note 20]*	0.150
CSA A23.2-14A	Concrete Prism Expansion (% maximum at 1 year) *[Note 19, Note 21]*	0.040

Note 18. A fine aggregate producing a colour darker than standard colour No. 3 shall be considered to have failed this requirement. A failed fine aggregate may be used if comparative mortar specimens prepared according to ASTM C87 meet the following requirements:

- Mortar specimens prepared using unwashed fine aggregate shall have a 7 day compressive strength that is a minimum of 95% of the strength of mortar specimens prepared using the same fine aggregate washed in a 3% sodium hydroxide solution. Type GU hydraulic cement shall be used.
- Setting time of the unwashed fine aggregate mortar specimens shall not differ from washed fine aggregate mortar specimens by more than 10%.

Note 19. The need for data to demonstrate compliance with this requirement shall be waived by the Contract Administrator if the aggregate source is on the current Ministry of Transportation's regional Aggregate Source List for Structural Concrete Fine and Coarse Aggregates.

Note 20. An aggregate that fails this requirement may be accepted provided the requirements of CSA A23.2-14A are met.

Note 21. An aggregate need only meet this requirement if it fails the requirements of CSA A23.2-25A. Test data shall have been obtained with the past 18 months from aggregate that is from the same source, processed in the same manner, as the material intended for use.

Greater detail, additional specifications and other aggregate product information can be obtained from the Ministry of Transportation. The above specifications are from MTO SP-110F11 (2007).