CONSTRUCTION SPECIFICATION FOR OPEN GRADED DRAINAGE LAYER

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320.01 SCOPE

This specification covers the requirements for materials, construction, and testing of asphalt cement and Portland cement treated open graded drainage layer.

320.02 REFERENCES

This specification refers to the following standards, specifications, and publications:

Ontario Provincial Standard Specifications, Construction

OPSS 313 Hot Mix Asphalt - End Result
OPSS 350 Concrete Pavement and Concrete Base

Ontario Provincial Standard Specifications, Material

OPSS 1103 Emulsified Asphalt
OPSS 1350 Concrete - Materials and Production

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:
LS-100 Rounding-Off of Test Data and Other Numbers
LS-601 Material Finer Than 75 μm Sieve in Mineral Aggregates by Washing

LS-602 Sieve Analysis of Aggregates
LS-604 Relative Density and Absorption of Coarse Aggregate
LS-606 Soundness of Aggregates by Use of Magnesium Sulphate
LS-608 Percent Flat and Elongated Particles in Coarse Aggregate
LS-614 Freezing and Thawing of Coarse Aggregates
LS-618 Resistance of Coarse Aggregate to Degradation by Abrasion in the Micro-Deval Apparatus
LS-625 Guidelines for Sampling of Granular Materials
LS-627 Open-Graded Drainage Layer (OGDL) Core Porosity Test
LS-630 Determination of Amount of Contamination of Coarse Aggregate
LS-631 Qualitative Determination of Presence of Plastic Fines in Aggregates

ASTM International

C174 / C174M - 17 Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores

320.03 DEFINITIONS

For the purpose of this specification, the definitions in OPSS 313 and OPSS 350 and the following definitions apply:

Delineator means the material used to delineate boundary between Portland cement treated open graded drainage layer and the overlying concrete slab to facilitate measurement of the slab thickness.

Design Lift Thickness means the thickness in millimetres of the OGDL lift as specified in the Contract Documents.

Drainage System means the OGDL, subdrains, and the lateral outlets.

Duplicate Samples means two samples taken at the same time and location - one to be used for quality assurance testing and the other for referee testing.

Mixture or Mix means open graded drainage layer material treated with either asphalt cement or Portland cement.

Open Graded Drainage Layer (OGDL) means a rapid draining layer located within the pavement structure that is covered either by concrete pavement, concrete base, or hot mix asphalt pavement and overlies the granular base course. The OGDL can be either Portland cement treated or asphalt cement treated.

Porosity of OGDL means the ratio of the volume of voids to total volume of OGDL as measured by LS-627.

320.04 DESIGN AND SUBMISSION REQUIREMENTS

320.04.01 Submission Requirements

The following information shall be submitted to the Contract Administrator at least three Days prior to placement of the OGDL:

a) Source(s) for the OGDL aggregate material.

b) Volumetric proportions for the OGDL mixture.

c) The type of plant to be used for OGDL mixture production and the plant location.

320.05 MATERIALS

320.05.01 General

Proportioning and mixing of OGDL materials shall produce a uniform homogenous mixture in which all particles of the aggregates are thoroughly and uniformly coated.

The porosity of the placed OGDL lift shall be 0.25 to 0.40, determined according to LS-627.

320.05.02 Aggregates

Aggregates for OGDL shall consist of 100% crushed particles produced by crushing bedrock material. Reclaimed materials or crushed reclaimed materials shall not be permitted.

The aggregates shall meet all of the requirements for gradation and physical properties shown in Tables 1 and 2.

320.05.03 Asphalt Cement Treated OGDL

Asphalt cement shall be according to the requirements for performance graded asphalt cement specified in the Contract Documents. The percentage by mass of asphalt cement in the mixture shall be $1.8 \pm 0.2\%$.

320.05.04 Portland Cement Treated OGDL

Cementing materials and water used in production of OGDL shall be according to OPSS 1350.

The mix shall contain 120 ± 10 kg/m^3 of Type GU Portland cement or Portland limestone cement (PLC) Type GUL. A portion of Portland or Portland limestone cement may be replaced by supplementary cementing materials as specified in OPSS 1350.

320.05.05 Delineator

The delineator shall consist of SS-1 emulsified asphalt according to OPSS 1103 diluted with an equal volume of water.

320.06 EQUIPMENT

320.06.01 Production Equipment

Portland cement treated OGDL mix shall be produced, mixed and delivered from a batching plant according to OPSS 1350.

320.06.02 Paving Equipment

Paving equipment shall not cause segregation of the material and shall place a uniform, homogeneous OGDL across the lane to the required grade and design lift thickness specified in the Contract Documents.

Paving equipment shall be self-propelled and capable of laying a consistent satisfactory mat that is true to the crossfall, profile, cross-section, and alignment specified in the Contract Documents.

320.06.03 Straight Edge

The straight edge shall be 3 m in length, metal, and have a level recessed in its upper edge parallel to the lower edge.

320.07 CONSTRUCTION

320.07.01 Operational Constraints

OGDL mixture shall not be placed in the rain and the ambient temperature at the time of mixture placement shall be above 2°C. Precautions shall be taken to protect placed plastic Portland cement treated OGDL from rain.

Traffic shall not be permitted on the OGDL with the exception of sampling equipment, equipment for the application of delineator, and the paving train during the placement of the overlying pavement.

Contamination of the OGDL by mud or other contaminants shall not be permitted.

All OGDL shall be covered with the overlying pavement within 30 Days following placement.

The subdrains and lateral outlets of the drainage system shall be operational prior to the placement of the OGDL.

320.07.02 Longitudinal and Transverse Joints

All joints shall be made to obtain a complete bond between the two OGDL edges and a smooth riding surface. Longitudinal and transverse joints shall be butt joints. The existing or previously placed OGDL edge shall be a straight clean vertical surface for the full depth of the OGDL. Where ramping or damage has occurred, trimming shall be required.

All dirt or other foreign material and all loose material shall be removed from all vertical surfaces. When matching a compacted joint, the depth of the uncompacted mat shall be set to allow for compaction.

320.07.03 Rolling

Rollers for compaction shall not be in vibration mode. Aggregate pick-up by the rollers shall be avoided. When water is used on the roller drums to prevent aggregate pick-up, free water shall not be allowed to fall onto the Portland cement treated OGDL surface.

320.07.04 Surface Tolerances

The surface shall be shaped and compacted so the finished surface does not deviate more than 10 mm from the grade and cross-section specified in the Contract Documents.

The surface tolerance shall be such that when tested with a 3 m straight edge placed in any direction on the surface except across the crown, there shall not be a gap greater than 5 mm between the bottom of the straight edge and the surface of the OGDL. Correction of the finished surface by grading or milling, or both, shall not be permitted.

320.07.05 Delineation

A delineator shall be placed on the Portland cement treated OGDL prior to placement of the overlying concrete pavement or concrete base.

The delineator shall be applied using self-propelled or towed pressure distributors capable of applying the product in a continuous and uniform manner over all of the OGDL to be overlaid.

320.07.06 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

320.08 QUALITY ASSURANCE

320.08.01 General

A laboratory designated by the Owner shall carry out acceptance testing.

The Owner shall be responsible for all costs associated with testing for Quality Assurance (QA) purposes, unless otherwise specified in this specification.

All test results shall be forwarded to the Contractor as they become available.

320.08.02 Sampling

The Contract Administrator shall be allowed access to all sampling locations and reserves the right to request a sample at any time.

All samples shall be placed in clean sample bags, then sealed and labelled, as specified in the Contract Documents.

All samples shall be accompanied by MTO Form PH-D-10.

320.08.02.01 Sampling of Aggregate for Gradation and Physical Properties

All aggregates samples shall be duplicate samples.

At least one duplicate 25 kg sample of aggregate from every lot of 50,000 m^2 or part thereof of OGDL being produced shall be obtained.

Additional samples shall also be taken whenever the aggregate changes to a new source or a new bench in a quarry. In this case, the existing lot shall be terminated and a new lot commenced.

Unless otherwise specified, all samples of aggregate shall be taken at the plant producing OGDL from individual stockpiles with a minimum quantity of 500 tonnes of aggregate, or at least 10% of the total quantity of aggregate requirement for the OGDL mix, unless otherwise directed by the Contract Administrator.

Sampling from stockpiles shall be according to LS-625. Each sample shall be treated as discrete sample and not combined or blended with any other sample.

320.08.02.02 Sampling of OGDL for Thickness and Porosity

The Contract Administrator shall establish the lot size as well as the number of sublots for thickness and porosity sampling, after discussions with the Contractor and prior to placement of the OGDL.

Lot size is generally 40,000 m^2 with the sublot size of 4,000 m^2. In all cases, a maximum allowable sublot numbers is 10 sublots per lot.

Within five Business Days of placement and prior to the placement of the overlying pavement layer, one intact 150 mm nominal diameter core shall be taken of the full depth of the OGDL for each sublot at a random location selected by the Contract Administrator.

Metal or cardboard containers that protect the integrity and shape of cores during transportation and until testing shall be used. When cores are taken the cores shall be intact and undamaged. If an intact and undamaged core cannot be obtained, then the sample shall be taken by saw cutting an intact sample with minimum dimensions of 140 by 140 mm square and maximum dimensions of 145 by 145 mm square. The sample shall be delivered intact and undamaged.

Immediately after sampling, each sample hole shall be filled with OGDL aggregate, treated with asphalt cement or Portland cement, up to the top of the surrounding OGDL.

320.08.03 Testing

320.08.03.01 Gradation and Physical Properties

Aggregates shall be tested according to Tables 1 and 2.

Aggregate shall be tested according to LS-614, unless written notification to the Contract Administrator to test according to LS-606 is received prior to sampling of the applicable materials for QA purposes. Unless the Contract Administrator has received such a request to replace LS-614 with LS-606, conformance to LS-614 shall be required.

When notification to replace LS-614 is received after QA testing using LS-614 has been initiated, the Owner shall charge $750.00 for each test initiated, which includes the cost of the testing using LS-614, administrative charges, and additional sampling, if required.

320.08.03.02 Thickness

One sample from each sublot shall be tested to determine the thickness of the OGDL according to ASTM C174. The test result for each sublot shall be used to compute the lot mean thickness calculated to one decimal place according to LS-100.

320.08.03.03 Porosity

The same sample used for the thickness determination from each sublot shall be tested to determine the porosity of the OGDL according to LS-627. The test result for each sublot shall be used to compute the lot mean porosity calculated to two decimal places according to LS-100.

320.08.04 Acceptance

Acceptance of OGDL shall be based on the gradation and physical properties of the aggregates used as well as the thickness, porosity, surface appearance and surface tolerance of the OGDL after placement.

320.08.04.01 Acceptance of Gradation and Physical Properties

The aggregates within a lot of OGDL shall be deemed to be acceptable, if the test results for the aggregate sample representing that lot meet all of the acceptance limit requirements specified in Tables 1 and 2.

If one or more test results for an aggregate sample representing a lot of OGDL do not meet all of those acceptance limit requirements, then the OGDL aggregates shall be removed from the Work and replaced according to the Repairing and Re-Decisioning subsection, or a price reduction applied at the discretion of the Contract Administrator. A price reduction may only be applied for each m^2 of OGDL left in the Work as long as the aggregate sample representing that lot are all within the price reduction range(s) specified in Tables 1 and 2.

If the QA test results of an aggregate sample representing a lot of OGDL for gradation and physical properties do not meet all the specified requirements and are not price adjusted, then all of the aggregates within that lot shall be rejected and any OGDL that includes those aggregates shall be removed from the Work and replaced at no additional cost to the Owner.

320.08.04.02 Acceptance of Surface Appearance

The surface appearance of the OGDL shall be assessed by the Contract Administrator based on visual surveys. The finished OGDL surface shall have a uniformly open texture and be free of loose aggregate. The OGDL shall be rejected if:

a) A single appearance of irregularity exceeds 5 m^2.

b) The combined area of multiple irregularities exceeds 10 m^2 over a 100 m^2 section.

c) Any OGDL identified by the Contract Administrator as being contaminated.

OGDL that is rejected for its appearance shall be repaired. OGDL that is repaired shall be re-decisioned according to the Repairing and Re-Decisioning subsection.

320.08.04.03 Acceptance of Surface Tolerance

All areas not meeting the surface tolerance requirements as specified in the Surface Tolerances subsection shall be rejected, repaired and re-decisioned according to the Repairing and Re-Decisioning subsection.

320.08.04.04 Acceptance of Thickness

Thickness acceptance shall be based on the mean of the lot, provided that no single sublot is deemed rejectable. A sublot shall be rejected, if the sublot thickness is less than 0.60 of the design lift thickness. Rejected sublots shall not be included in the lot mean thickness calculation.

If the lot mean thickness is greater than or equal to the design lift thickness, the item shall be accepted without any price reduction for thickness.

If the lot mean thickness is less than the design lift thickness, but greater than or equal to 0.75 of the design lift thickness, the lot shall be subject to a price reduction calculated using the pay factors given in Table 3.

The lot shall be rejected, if the lot mean thickness is less than 0.75 of the design lift thickness.

If repair to the lot is chosen in lieu of a price reduction or if a rejected lot requires repair, the lot shall be repaired and decisioned according to the Repairing and Re-Decisioning subsection.

320.08.04.05 Acceptance of Porosity

Acceptance for the porosity of OGDL shall be based on the lot mean for the porosity of OGDL, and the porosity of individual sublots.

A sublot shall be rejected if the porosity of OGDL is less than 0.20 or greater than 0.50. Rejected sublots shall not be included in the lot mean porosity calculation and shall be repaired according to the Repairing and Re-Decisioning subsection.

The lot shall be accepted if the lot mean porosity of OGDL is greater than or equal to 0.25, and less than or equal to 0.40, and with less than 30% of sublots with porosity outside the range of 0.25 to 0.40.

If the lot mean porosity of OGDL is greater than or equal to 0.25, and less than or equal to 0.40, and with more than 30% of sublots with porosity outside the range of 0.25 to 0.40, those sublots outside the range shall require repair until more than 30% of sublots are within the range of 0.25 to 0.40 for the porosity.

If the lot mean porosity of OGDL is greater than or equal to 0.20 and less than 0.25, or greater than 0.40 and less than or equal to 0.50, the lot shall be subjected to a price reduction calculated using the pay factors in Table 4. If repair to the sublots is chosen in lieu of a payment adjustment, the sublots shall be repaired and re-decisioned according to the Repairing and Re-Decisioning subsection.

If the lot mean porosity of OGDL is less than 0.20 or greater than 0.50, the lot shall be rejected, repaired and re-decisioned according to the Repairing and Re-Decisioning subsection.

320.08.04.06 Referee Testing for Gradation and Physical Properties

Referee testing may be invoked for one or more attributes by submitting a written request to the Contract Administrator, within five Business Days following notification that a sample representing a lot of OGDL does not meet the requirements of this specification.

Referee testing shall be carried out, as specified herein and as specified in the Contract Documents.

The retained duplicate QA aggregates samples shall be used for referee testing.

All referee test results for a lot shall replace the respective QA tests for acceptance of the applicable lot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the referee test results, the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory, at the rates as specified in the Contract Documents shall be at no additional cost to the Owner. In all other cases, the Owner shall bear the cost of the referee testing and the cost of transporting the samples of that lot.

320.08.04.07 Re-test for Thickness and Porosity

Re-testing for thickness or porosity or both may be invoked by submitting a written request to the Contract Administrator, within five Business Days following notification that any QA samples representing a lot or sublot of OGDL fails to meet the requirements of this specification.

The re-test shall be carried out on the same QA sample, as specified herein and as specified in the Contract Documents. Witnessing of the re-test of the same QA samples for thickness or porosity or both is permitted.

All re-test results for a lot or sublot shall replace the respective QA tests for acceptance of the applicable lot or sublot and shall be binding on both the Owner and the Contractor.

If a lot is not accepted at full payment based on the re-test results, the cost of the re-testing of that lot shall be at no additional cost to the Owner. In all other cases, the Owner shall bear the cost of the re-testing.

320.08.05 Repairing and Re-Decisioning

320.08.05.01 General

All repairs including removals and replacements to OGDL shall be full lane or shoulder width and a sufficient length for the repair to be carried out employing the same equipment used during initial placement of the OGDL with the exception of repairs for surface deficiencies in surface tolerance. OGDL used for repairs shall meet the requirements of this specification.

All repairs shall be carried out at no additional cost to the Owner.

320.08.05.02 Gradation and Physical Properties

Any OGDL that includes rejected aggregates, as specified in the Acceptance of Gradation and Physical Properties clause, shall be removed and replaced.

320.08.05.03 Surface Appearance

Rejected OGDL due to surface irregularities or contamination shall be removed and replaced.

320.08.05.04 Surface Tolerance

Where the finish grade of OGDL is below the design grade, the final grade of the pavement shall be corrected with an additional thickness of overlying surface material. Patching on the surface of OGDL shall not be permitted. If the finish grade of OGDL is above the design grade, the overlying surface material shall follow the design thickness. Milling on the surface of OGDL shall not be permitted.

320.08.05.05 Thickness and Porosity

For each sublot or lot that is rejected due to thickness or porosity or both, or chosen for repair, the entire sublot of OGDL shall be removed and replaced.

When repairs are made to rejected sublots or lot or those sublots that are chosen for repair due to non-conformance, the original lot and replaced sublots shall be re-evaluated and re-decisioned for acceptance.

The original lot shall be divided into two reconfigured lots in the following way: All non-replaced sublots shall be grouped as one lot; The remaining sublots (i.e., replaced sublots) shall be grouped as another lot. Lot mean thickness and lot mean porosity shall be re-calculated for both reconfigured lots and shall be re-decisioned for either in payment at the full Contract price, subjected to a payment reduction, or deemed rejectable.

320.09 MEASUREMENT FOR PAYMENT

320.09.01 Actual Measurement

320.09.01.01 Open Graded Drainage Layer

Measurement of OGDL shall be by area in square metres.

320.09.02 Plan Quantity Measurement

When measurement is by Plan Quantity, such measurement shall be based on the units shown in the clause under Actual Measurement.

320.10 BASIS OF PAYMENT

320.10.01 Open Graded Drainage Layer - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment, and Material to do the work, except as otherwise specified herein.

When test results show that either the thickness payment factor or porosity of OGDL payment factor for the lot is less than 1.000, the payment reduction for the lot shall be as follows.

$$(2.000 - PF_T - PF_P) \times \text{item price} \times \text{lot quantity}$$

Where: PF_T and PF_P are calculated according to Table 3 and 4, respectively.

In addition, any OGDL that contains aggregates that do not meet any of the requirements for gradation or physical properties as specified in the Acceptance of Gradation and Physical Properties clause shall be subject to a 10% payment reduction.

For purposes of payment reduction, the term item price means the Contract price of the Open Graded Drainage Layer item.

TABLE 1
Gradation Requirements (LS-602)

Percentage Passing By Mass of Aggregate (Note 1)		
Sieve Designation	**Acceptance Limit**	**Price Reduction Range(s)**
37.5 mm	100	90.1 – 100
26.5 mm	95.0 – 100	85.5 – 94.9
19.0 mm	90.0 – 100	81.1 – 89.9
16.0 mm	65.0 – 100	58.5 – 64.9
13.2 mm	40.0 – 86.0	36.1 – 39.9 or 86.1 – 94.6
9.5 mm	20.0 – 55.0	18.1 – 19.9 or 55.1 – 60.5
4.75 mm	0 – 10.0	10.1 – 12.0
2.36 mm	0 – 5.0	5.1 – 6.0
75 μm	0 – 2.0	2.1 – 2.4

Notes:

1. All results are rounded to one decimal place according to LS-100.

TABLE 2
Physical Property Requirements

MTO Test Number	Laboratory Test	Acceptance Limit	Price Reduction Range
LS-601	Wash Pass 75μm sieve, Guideline B, % maximum	2.0	2.1 - 2.2
LS-604	Absorption, % maximum	2.0	2.1 - 2.2
LS-608	Flat and Elongated Particles, % maximum (4:1)	20.0	20.1 - 22.0
LS-614	Unconfined Freeze-Thaw, % maximum loss (Note 1)	15.0	15.1 - 18.8
LS-618	Micro-Deval Abrasion, % maximum loss	21.0	21.1 - 23.1
LS-630	Amount of Contamination, % maximum	1.0 (Note 2)	≤1.1 (Note 2)
LS-631	Plastic Fines	NP (Non-Plastic)	NP (Non-Plastic)
Alternative Requirement for LS-614			
LS-606	Magnesium Sulphate Soundness, % maximum loss (Note 1)	15.0	15.1 - 18.8

Notes:

1. The Owner shall waive the requirements for LS-614, Unconfined Freeze-Thaw, provided the Contractor has submitted a written request that the aggregate meet the alternative requirements for LS-606, Magnesium Sulphate Soundness.
2. Combined amount of wood, clay brick and/or gypsum and/or gypsum wall board or plaster, etc. shall not exceed the maximum percentages by mass shown above.
3. All results are rounded to one decimal place according to LS-100.

TABLE 3
Thickness Payment Factors

Acceptance Criteria	Classification	Payment Factor, PF_T
$T_C \geq T_D$	Acceptable	1.000
$0.9T_D \leq T_C < 1.0T_D$	Payment Reduction	T_C/T_D
$0.75T_D \leq T_C < 0.9T_D$	Payment Reduction	$(T_C/T_D)^{1.5}$

Where:

T_D is the OGDL design lift thickness specified in the Contract Documents in millimetres.

T_C is the mean thickness of OGDL of the lot in millimetres calculated to one decimal place according to LS-100.

PF_T is the payment factor for thickness of the OGDL of the lot calculated to three decimal places according to LS-100.

TABLE 4
Porosity of OGDL Payment Factors

Acceptance Criteria	Classification	Payment Factor, PF_P
$0.25 \leq n_c \leq 0.40$ with **less** than 30% of sublots with porosity outside the range of 0.25 to 0.40	Acceptable	1.000
$0.20 \leq n_c < 0.25$	Payment Reduction	$1 - 4(0.25 - n_c)$
$0.40 < n_c \leq 0.50$	Payment Reduction	$1 - 2(n_c - 0.4)$

Where:

PF_P is the payment factor for porosity of OGDL of the lot calculated to three decimal places according to LS-100.

n_c is the mean porosity of OGDL of the lot calculated to two decimal places according to LS-100.