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REVISION INFORMATION SHEET

ONTARIO PROVINCIAL STANDARDS FOR ROADS AND PUBLIC WORKS

VOLUME 5 PROVINCIAL-ORIENTED MTO GENERAL CONDITIONS OF CONTRACT AND GENERAL AND CONSTRUCTION SPECIFICATIONS

MANUAL REVISION #11

APRIL 2016

UPDATING ONTARIO PROVINCIAL STANDARDS FOR YOUR USE

Each roads and public works owner (Owner) is responsible for determining implementation dates and directions for use of Ontario Provincial Standards; therefore, manual holders are cautioned about immediately discarding superseded and cancelled standards.

A NOTE TO DESIGNERS OF MUNICIPAL CONTRACTS REGARDING APPENDICES

There are a number of OPS specifications published with appendices containing supplemental requirements that modify the specification. These specifications contain information written for use in provincial contracts. The appendices contain supplemental requirements that modify the provincial requirements so the specifications can be used in municipal contracts. The specifications are easily identified, as the table of contents for each specification lists the appendix containing the supplemental requirements (e.g., Supplemental Requirements for Using OPSS XXX in Municipal Contracts).

Designers of municipal contracts should review each specification to determine if the supplemental requirements should be invoked in their contracts. To ensure completeness of municipal Contract Documents, designers should invoke the appendices by referencing them in the Contract Documents.

ACCESSING AND OBTAINING ONTARIO PROVINCIAL STANDARDS

The Ontario Provincial Standards for Roads and Public Works (OPS) manuals and the latest published updates for each of the eight OPS manuals are available as follows:

- Available electronically on the OPS/MTO website. Online access to the current, updated, and archived standards; indexes; OPS User Notes; and publication Revision Information Sheets are available free of charge at the site.
(<http://www.raqs.mto.gov.on.ca/techpubs/ops.nsf/OPSHomepage>)
- Hard-copy format available from Publications Ontario by telephone at 1-800-668-9938 or online. Updates and OPS manuals are available for a cost-recovery fee.
(www.publications.serviceontario.ca)

- The eight OPS manuals of standards are available on one CD in PDF format. The OPS drawings published in Volumes 3 and 4 are available in AutoCAD format on a separate CD. These CDs are available from Publications Ontario or by telephone at 1-800-668-9938 or online for a cost-recovery fee. The updates are not available on CDs as an update package.
(www.publications.serviceontario.ca)

At the Publications Ontario web page, you can type "Ontario Provincial Standards," "OPS," "OPSS," or "OPSD" in the search box, and all related products for the Ontario Provincial Standards will be listed, click on the item you wish to purchase, add the item to your cart, then follow the instructions to complete your order. If trying to order an OPS product online from Publications Ontario and it is shown as Out of Stock, you can backorder the product by telephone at 1-800-668-9938.

In order to receive the Municipal Engineers Association (MEA) purchase price, MEA members should visit the MEA website (www.municipalengineers.on.ca/) for the MEA Publications Ontario order form for hard-copy manuals and CDs.

MTO employees should contact Simon Leung, Account Representative at Publications Ontario, by email (simon.leung@ontario.ca) to set up an account in order to receive the MTO purchase price for technical publications, including the Ontario Provincial Standards.

Links to Publications Ontario and the Ontario Provincial Standards on the MTO Library website are available on the OPS website (www.ops.on.ca). Also on this site under News and Activities are notices for updates and changes in OPS.

Questions should be directed by email to Ontario.Prov.Standards@ontario.ca.

YOU SHOULD REGISTER YOUR OPS MANUALS AND CDs

Users of OPS do not receive notices of OPS updates as they had in the past. Methods of notification from Publications Ontario for the future are being investigated, and you will be informed of them as they become available. In the interim, an email will be sent to OPS users who have registered their OPS manuals and CDs with OPS.

Owners of OPS manuals, who have not yet done so, are requested to register their OPS hard-copy manuals and CDs with OPS by email at Ontario.Prov.Standards@ontario.ca. The registration form and submission instructions are available on the OPS website (www.ops.on.ca), Miscellaneous Info, OPS Forms.

WAITING TO HEAR FROM YOU

If you have a suggestion to revise a standard or you have a standard that works in your ministry, municipality, or area, send it to the Head, OPS Administration, for review and possible inclusion into the Ontario Provincial Standards.

THIS MANUAL IS REVISED AS FOLLOWS:

Index Pages Volume 5

Remove the entire index and replace with the revised index.

Standard Specifications Volume 5

Superseded/Cancelled (Remove)		Revised/New (Insert)		Remarks
OPSS.PROV	Dated	OPSS.PROV	Dated	
320	November 2014	320	April 2016	“CONSTRUCTION SPECIFICATION FOR OPEN GRADE DRAINAGE LAYER” See Summary of Revisions.
732	November 2014	732	April 2016	“CONSTRUCTION SPECIFICATION FOR GUIDE RAIL END TREATMENT – STEEL BEAM ENERGY ATTENUATING TERMINAL SYSTEMS” See Summary of Revisions.
		903	April 2016	“CONSTRUCTION SPECIFICATION FOR DEEP FOUNDATIONS” See Summary of Revisions.

SUMMARY OF REVISIONS TO OPSS.PROV 320

CONSTRUCTION SPECIFICATION FOR OPEN GRADE DRAINAGE LAYER

- Section 320.02, References, OPSS 310, 1003, 1150, 1151, 1301, 1302; MTO Publication LS-604, LS-606, LS-608, LS-614, LS-618, LS-625, LS-630, LS-631 added.
- Section 320.03, Definitions, Duplicate Samples added.
- Section 320.04, Design and Submission Requirements, rewritten.
- Section 320.05, Materials, rewritten.
- Section 320.06, Equipment, rewritten.
- Section 320.07, Construction, rewritten.
- Section 320.08 Quality Assurance, rewritten.
- Section 320.10 Basis of Payment, rewritten.
- Table 1, Gradation Requirements (LS-602), revised.
- Table 2, Thickness Payment Factors revised and renumbered Table 3.
- Table 3, Porosity of OGD L Payment Factors revised and renumbered Table 4.
- New table, Table 2, Physical Property Requirements, added.

SUMMARY OF REVISIONS TO OPSS.PROV 732

CONSTRUCTION SPECIFICATION FOR GUIDE RAIL END TREATMENT – STEEL BEAM ENERGY ATTENUATING TERMINAL SYSTEMS

- Subsection 732.07.01, General; 2nd paragraph, new d) added; existing 3rd paragraph deleted. New Type M list added.
- Subsection 732.07.03, Steel Beam Guide Rail, 2nd paragraph, 2nd sentence; converted into Table 1 and new Table 2.
- Clause 732.09.01.01, Extruder Terminal System and Sequential Kinking Terminal System deleted.
- Subsection 732.10.01, Extruder Terminal System and Sequential Kinking Terminal System deleted.

SUMMARY OF REVISIONS TO OPSS.PROV 903

CONSTRUCTION SPECIFICATION FOR DEEP FOUNDATIONS

- This is a new PROV to replace OPSS 903 Nov 2009.
- Clause 903.07.02.02, Driving Shoes and Rock Points, has been rewritten
- Clause 903.07.02.07.01, General, first paragraph has been rewritten.
- Subsection 903.07.04, Displacement Caisson Piles, last sentence has been rewritten.
- Clause 903.07.08.03, Certificate of Conformance, has been rewritten.

MANUAL REVISION RECORD

Provincial-Oriented

Volume 5 – MTO General Conditions of Contract and General & Construction Specifications

This record should remain in the manual at all times. Revisions are numbered sequentially. This sheet should be filled in after each revision has been placed into the manual. It will quickly indicate to users whether the contents of the manual are up-to-date.

REVISION NUMBER	REVISION DATE	ENTERED BY	REVISION NUMBER	DATE	ENTERED BY
1	APRIL 2008	Included in new manuals	27		
2	NOV 2008	Included in new manuals	28		
3	APR 2010	Included in new manuals	29		
4	NOV 2010	Included in new manuals	30		
5	APR 2012	Included in new manuals	31		
6	NOV 2012	Included in new manuals	32		
7	NOV 2013	Included in new manuals	33		
8	NOV 2014	Included in new manuals	34		
9	APRIL 2015	Included in new manuals	35		
10	NOV 2015	Included in new manuals	36		
11	APRIL 2016	Included in new manuals	37		
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MTO GENERAL CONDITIONS OF CONTRACT		
APR 2010	100	MTO General Conditions of Contract
DIVISION 1 - GENERAL SPECIFICATIONS		
NOV 2008	106	Notice to Users of OPSS 106 (Electrical Work)
NOV 2014	120	The Use of Explosives
NOV 2015	182	Environmental Protection for Construction in and Around Waterbodies and on Waterbody Banks
NOV 2012	185	Temporary Flow Control for Construction in Waterbodies
DIVISION 2 - GENERAL GRADING		
NOV 2013	202	Rock Removal by Manual Scaling, Machine Scaling, Trim Blasting, or Controlled Blasting
NOV 2014	203	Rock Stabilization
NOV 2014	206	Grading
NOV 2014	209	Embankments Over Swamps and Compressible Soils
NOV 2013	212	Earth Borrow
NOV 2014	220	Wick Drain Installation
DIVISION 3 - PAVEMENT (FLEXIBLE AND RIGID)		
APR 2012	308	Tack Coating and Joint Painting
APR 2007	313	Hot Mix Asphalt - End Result
NOV 2015	314	Untreated Subbase, Base, Surface, Shoulder, Selected Subgrade, and Stockpiling
APR 2016	320	Open Graded Drainage Layer
NOV 2014	330	In-Place Full Depth Reclamation of Bituminous Pavement and Underlying Granular
NOV 2015	331	Full Depth Reclamation with Expanded Asphalt Stabilization
NOV 2015	333	Cold In-Place Recycling
NOV 2015	335	Cold In-Place Recycling with Expanded Asphalt



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NOV 2015	342	Grinding of Centreline and Shoulder Rumble Strips in Asphalt
NOV 2014	355	Installation of Interlocking Concrete Pavers
NOV 2014	363	Repairing Rigid Pavement with Precast Concrete Slabs
NOV 2014	365	Cross-Stitching Longitudinal Cracks in Concrete Pavement and Concrete Base
DIVISION 4 - DRAINAGE, WATERMAINS, AND UTILITY		
NOV 2015	401	Trenching, Backfilling, and Compacting
NOV 2015	410	Pipe Sewer Installation in Open Cut
NOV 2015	421	Pipe Culvert Installation in Open Cut
DIVISION 5 - MISCELLANEOUS		
NOV 2014	501	Compacting
NOV 2014	510	Removal
NOV 2014	512	Installation of Gabions
NOV 2014	539	Temporary Protection Systems
DIVISION 6 - ELECTRICAL		
CURRENTLY NO SPECIFICATIONS		
DIVISION 7 - TRAFFIC SAFETY		
NOV 2015	721	Steel Beam Guide Rail and Cable Guide Rail
NOV 2015	723	Energy Attenuators
APR 2016	732	Guide Rail End Treatment - Steel Beam Energy Attenuating Terminal Systems
NOV 2014	771	Standard Highway Fence
DIVISION 8 - ENVIRONMENTAL AND LANDSCAPE		
NOV 2014	804	Seed and Cover
DIVISION 9 - STRUCTURAL		
APR 2016	903	Deep Foundations



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DATE	SPEC. NO. OPSS.PROV	TITLE
NOV 2014	905	Steel Reinforcement for Concrete
NOV 2014	908	Metal Traffic Barriers and Metal Railings for Structures
APR 2008	910	Stressing Systems for Post-Tensioning
NOV 2014	911	Coating Structural Steel Systems
NOV 2014	914	Waterproofing Bridge Decks with Applied Asphalt Membrane
NOV 2014	915	Sign Support Structures
NOV 2008	920	Deck Joint Assemblies, Preformed Seals, Joint Fillers, Joint Seals, Joint Sealing Compounds, and Waterstops - Structures
APR 2012	928	Structure Rehabilitation - Concrete Removal
NOV 2014	930	Structure Rehabilitation - Concrete Patches, Refacing, and Overlays
NOV 2014	935	Impressed Current Cathodic Protection System for Bridge Structures



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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.

320.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

320.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

320.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

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

C 174/C 174M-06 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, 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 3 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 be of sufficient accuracy and duration to 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 used.

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 $120 \pm 10 \text{ kg/m}^3$ 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 Curing of Portland Cement Treated OGDL

Portland cement treated OGDL mixture shall be cured using moisture vapour barrier. The moisture vapour barrier shall be a white opaque polyethylene film according to ASTM C 171, at least 100 µm thick.

The moisture vapour barrier shall be placed on the surface of OGDL immediately after compaction of the OGDL and within 2 to 4 metres of the compacting operation. Air flow in the space between the moisture vapour barrier and OGDL surface shall be prevented. The moisture vapour barrier strips shall overlap 150 mm and shall be held in place at the edges and laps to prevent displacement without marring the surface of the OGDL. Curing shall continue for a minimum of 48 hours and until the OGDL has gained sufficient strength to support the paving equipment.

320.07.03 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.

320.07.04 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.

320.07.05 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.

320.07.06 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.

320.07.07 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 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 provided by the Contractor, 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.

The Contractor shall obtain at least one duplicate 25 kg sample of aggregate from every lot of 100,000 m² or part thereof of OGDL being produced.

Additional samples shall also be taken whenever the aggregate changes to a new source or a new bench in a quarry or whenever a significant change in aggregate production or material occurs that may affect the quality of the material. 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 m². In all cases, the subplot size shall not exceed 4,000 m².

Within 5 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 subplot at a random location selected by the Contract Administrator.

The Contractor shall supply suitable metal or cardboard containers that protect the integrity and shape of cores during transportation and until testing. The cores shall be taken in such a manner as to avoid sample damage. 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 of this specification.

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 Contractor shall be charged \$600.00 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 subplot shall be tested to determine the thickness of the OGDL according to ASTM C 174/C 174M. The test results for each subplot shall be used to compute the lot mean calculated to one decimal place for thickness according to LS-100.

320.08.03.03 Porosity

One sample from each subplot shall be tested according to LS-627 to determine the porosity of the OGDL, calculated to three 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 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 m² 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 requirements listed above and are not price adjusted, then all of the aggregates within that lot shall be considered rejectable 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 rejectable if:

- a) A single appearance of irregularity exceeds 5 m².
- b) The combined area of multiple irregularities exceeds 10 m² over a 100 m² section.
- c) Any OGDL identified by the Contract Administrator as being contaminated.

OGDL that is rejected for its appearance shall be repaired. OGD L 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 subplot is deemed rejectable. A subplot shall be rejectable, if the subplot thickness is less than 0.60 of the design lift thickness. Rejectable sublots shall not be included in the lot mean thickness calculation.

If the lot mean thickness is equal to or greater than 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 rejectable, if the lot mean thickness is less than 0.75 of the design lift thickness.

If the Contractor elects to repair the lot in lieu of a price reduction or if a rejectable 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

The test results for each subplot shall be used to compute the lot mean for the porosity of OGD L, and the porosity is calculated to two decimal places according to LS-100. Acceptance for the porosity of OGD L shall be based on the lot mean for the porosity of OGD L, and the porosity of individual sublots.

A subplot shall be rejectable if the porosity of OGD L is less than 0.20 or greater than 0.50. Rejectable 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 OGD L is equal to or greater than 0.25, and equal to or less than 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 OGD L is equal to or greater than 0.25, and equal to or less than 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.

The lot shall be rejectable if the lot mean porosity of OGD L is less than 0.20 or greater than 0.50, and shall be repaired according to the Repairing and Re-Decisioning subsection.

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

320.08.04.06 Referee Testing for Gradation and Physical Properties

The Contractor may invoke referee testing for one or more attributes by submitting a written request to the Contract Administrator, within 5 Business Days following notification that a sample representing a lot of OGD L does not meet the requirements of this specification.

Referee testing shall be carried out, as specified herein and elsewhere 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, then the Contractor shall be responsible for the cost of the referee testing of that lot, including the cost of transporting the samples to the referee laboratory, at the rates specified elsewhere in the Contract Documents. 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

The Contractor may invoke re-testing for thickness and porosity by submitting a written request to the Contract Administrator, within 5 Business Days following notification that a sample representing a lot of OGDL does not meet the requirements of this specification.

The re-test shall be carried out on the same QA sample, as specified herein and elsewhere in the Contract Documents.

The Contractor may be present to witness the re-test of the same QA samples for thickness and porosity.

All re-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 re-test results, then the Contractor shall be responsible for the cost of the re-testing of that lot. 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 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 rejectable aggregates, as specified in the Acceptance of Gradation and Physical Properties clause, shall be removed and replaced.

320.08.05.03 Surface Appearance

Rejectable 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 subplot that is rejectable due to thickness or porosity or both, the entire subplot of OGDL shall be removed and replaced.

When repairs are made to rejectable sublots or those sublots that the Contractor elects to repair due to non-conformance, the lot shall be re-evaluated and re-decided for payment reduction. The original lot shall be divided into two reconfigured lots in the following way: All acceptable sublots shall be grouped as one lot and shall receive the full Contract price. The remaining sublots shall be grouped as another lot and shall use the retest results of the repaired sublots to calculate the mean lot, and shall be accepted either at the full Contract price, or 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 and the lot is not repaired, 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 the requirements for gradation and physical properties shall also be subject to a 10% payment reduction, as specified in the Acceptance Based on Gradation and Physical Properties clause.

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 – 100	85.5 – 94.9
19.0 mm	90 – 100	81 – 89.9
16.0 mm	65 – 100	58.5 – 64.9
13.2 mm	40 – 86	36 – 39.9 or 86.1 – 94.6
9.5 mm	20 – 55	18 – 19.9 or 55.1 – 60.5
4.75 mm	0 – 10	10.1 – 12
2.36 mm	0 – 5	5.1 – 6
75 µm	0 – 2	2.1 – 2.4
Notes: 1. The grading of OGD L may not necessarily meet all of the limits shown in this table, as long as all other requirements specified herein and elsewhere in this Contract have been met. 2. All results are rounded to one decimal place.		

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	20.1 - 22.0
LS-614	Unconfined Freeze-Thaw, % maximum loss (Note 1)	15	15.1 - 18.8
LS-618	Micro-Deval Abrasion, % maximum loss	21	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)	≤2.0
Alternative Requirement for LS-614			
LS-606	Magnesium Sulphate Soundness, % maximum loss (Note 1)	15	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.			

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 of the lot sample perpendicular height thickness in millimetres calculated to one decimal place according to LS-100.

PF_T is the payment factor for thickness 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 0.4	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.

Appendix 320-A, April 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



**CONSTRUCTION SPECIFICATION FOR
GUIDE RAIL END TREATMENT - STEEL BEAM
ENERGY ATTENUATING TERMINAL SYSTEMS**

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732-A	Commentary
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732.01	SCOPE
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This specification covers the requirements for the installation of steel beam energy attenuating terminal (SBEAT) systems.

732.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

732.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

732.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

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

Ontario Provincial Standard Specifications, Material

OPSS 1601 Wood, Preservative Treatment, and Shop Fabrication

Ontario Ministry of Transportation Publications

Ontario Traffic Manual (OTM):
Book 6 - Warning Signs

ASTM International

A 123/A 123M-09 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A 780/A 780M-09 Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings

732.04 DESIGN AND SUBMISSION REQUIREMENTS

732.04.01 Submission Requirements

One copy of the manufacturer's installation instructions and Working Drawings for each type of SBEAT system to be installed shall be submitted to the Contract Administrator.

Installation of the SBEAT system shall not commence until the Contract Administrator has received the copy of the installation instructions and Working Drawings.

732.05 MATERIALS

732.05.01 General

All supplied system components shall be according to the manufacturer's specifications.

732.05.02 U Channel Posts

Posts shall be 2.44 m long perforated steel U channel with 11 mm diameter holes spaced on 50 mm centres, minimum weight of 4.46 kg/m, and hot dip galvanized according to ASTM A 123/A 123M.

732.07 CONSTRUCTION

732.07.01 General

SBEAT systems shall be installed according to manufacturer's instructions at the locations specified in the Contract Documents.

When an SBEAT system is specified in the Contract Documents, the Contractor has the option of using one of the following systems:

- a) Extruder Terminal system
- b) Sequential Kinking Terminal system
- c) X-Lite Tangent Terminal system
- d) SoftStop Terminal system

When an SBEAT Type M system is specified in the Contract Documents, the Contractor has the option of using one of the following systems:

- a) MGS – ET-Plus 31 Terminal System
- b) MGS – SoftStop Terminal System
- c) MGS – Sequential Kinking Terminal System
- d) MGS – X-Lite Terminal System

SBEAT systems with steel posts shall be installed to steel beam guide rail systems with steel posts.

SBEAT systems with wooden posts shall be installed to steel beam guide rail systems with wooden or steel posts.

SBEAT systems shall be installed according to the manufacturer's instructions at locations as specified in the Contract Documents using only the components supplied for a particular SBEAT system unit.

A minimum 2 m wide area behind the posts, measured from the back of the posts shall be clear of all obstacles for the entire length of the SBEAT system.

732.07.02 Posts and Steel Foundation Tubes

All posts and steel foundation tubes shall be set to the depth and alignment at locations specified in the Contract Documents, regardless of the material encountered.

Wooden post tops shall be cut to the height and to the chamfer as specified in the Contract Documents.

All holes shall be drilled in the wooden posts prior to installation and in the steel posts prior to galvanizing.

The predrilled holes and the cut tops of the wooden posts shall be treated with two coats of an approved wood preservative according to OPSS 1601.

All lower hinge break away posts, steel foundation tubes, and soil plates shall be installed so that no more than 100 mm is exposed above finished grade.

732.07.03 Steel Beam Guide Rails

SBEAT systems shall be connected to new or existing steel beam guide rail as specified in the Contract Documents.

SBEAT system and SBEAT Type M System mounting heights shall be measured vertically from the top of the steel beam guide rail to the ground or gutter line. SBEAT system mounting heights shall be within the ranges in Table 1. SBEAT Type M system mounting heights shall be within the ranges in Table 2.

Where curb with gutter is required, steel beam guide rail mounting height shall be measured:

- a) Vertically at face of steel beam guide rail, when face of steel beam guide rail is more than 300 mm beyond gutter line.
- b) Vertically at gutter line, when face of steel beam guide rail is 300 mm or less beyond the gutter line.

Channel shall not be used within the SBEAT system.

732.07.04 Damage to Galvanizing

Precautions shall be taken to protect galvanizing against damage. Minor abrasions shall be repaired according to ASTM A 780/A 780M. Components with major abrasions shall be replaced.

The method of repair for any damage shall be approved by the Contract Administrator prior to the commencement of such work.

732.07.05 Object Markers and Oversize Plow Markers

A Wa-33 object marker according to OTM Book 6, a Wz-2 oversize snow plow marker, and galvanized mounting hardware shall be installed at each energy attenuator.

When installed on a paved surface, the object marker and oversize snow plow marker shall be integrally attached to a surface mounted flexible post. The signs and post shall be supplied by the manufacturer as a complete unit. The post shall have the ability to bend 90 degrees from vertical and self-restore after impacts. The minimum outside diameter of the post shall be 60 mm. The post shall be anchored to the pavement according to the manufacturer's recommendations.

When installed on a granular surface, the Wa-33 object marker and Wz-2 oversize snow plow marker shall be securely fastened to a U channel post and the post shall be direct buried to a minimum embedment depth of 900 mm.

Posts shall be installed at locations as specified in the Contract Documents.

732.07.06 Management of Excess Material

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

732.09 MEASUREMENT FOR PAYMENT

732.09.01 Actual Measurement

732.09.01.01 Steel Beam Energy Attenuating Terminal System

For measurement purposes, a count shall be made of each complete steel beam energy attenuating terminal system installed, regardless of the type of steel beam energy attenuating terminal system placed.

732.09.02 Plan Quantity Measurement

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

732.10 BASIS OF PAYMENT

732.10.01 Steel Beam Energy Attenuating Terminal System - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

Costs associated with any required removals and replacement or repairs of defective materials shall be the Contractor's responsibility at no additional cost to the Owner.

TABLE 1
SBEAT System Mounting Heights

System	Height During Construction and Seasonal Shutdown mm	Height for Completion of the Work mm
Extruder Terminal	685 to 760	685 to 735
Sequential Kinking Terminal	685 to 760	685 to 735
X-Lite Tangent Terminal	685 to 760	685 to 735
SoftStop Terminal	760 to 810	760 to 810

TABLE 2
SBEAT Type M System Mounting Heights

System	Height During Construction and Seasonal Shutdown mm	Height for Completion of the Work mm
MGS ET-Plus 31 Terminal	760 to 810	760 to 810
MGS SoftStop Terminal	760 to 810	760 to 810
MGS Sequential Kinking Terminal	760 to 810	760 to 810
MGS X-Lite Tangent Terminal	760 to 810	760 to 810

Appendix 732-A, April 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.



CONSTRUCTION SPECIFICATION FOR DEEP FOUNDATIONS

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903-A	Commentary
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903.01	SCOPE
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This specification covers the requirements for the supply and installation of deep foundation units.

903.01.01 Specification Significance and Use

This specification is written as a provincial-oriented specification. Provincial-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of the Ontario Ministry of Transportation.

Use of this specification or any other specification shall be according to the Contract Documents.

903.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

903.02 REFERENCES

When the Contract Documents indicate that provincial-oriented specifications are to be used and there is a provincial-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.PROV, unless use of a municipal-oriented specification is specified in the Contract Documents. When there is not a corresponding provincial-oriented specification, the references below shall be considered to be to the OPSS listed, unless use of a municipal-oriented specification is specified in the Contract Documents.

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

Ontario Provincial Standard Specifications, Construction

OPSS 904	Concrete Structures
OPSS 905	Steel Reinforcement for Concrete
OPSS 909	Prestressed Concrete - Precast members
OPSS 911	Coating Structural Steel Systems

Ontario Provincial Standard Specifications, Material

OPSS 1302	Water
OPSS 1350	Concrete - Materials and Production
OPSS 1440	Steel Reinforcement for Concrete

CSA Standards

G40.20-04/G40.21-04 (R2009)	General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel
CAN3-056-1962(R2006)	Round Timber Piles
O80 Series-08	Wood Preservation
W47.1-03 (R2008)	Certification of Companies for Fusion Welding of Steel
W48-06	Filler Materials and Allied Materials for Shielded Metal Arc Welding
W59-03(R2008)	Welded Steel Construction (Metal Arc Welding)
W178.1-08	Certification of Welding Inspection Organizations
W178.2-08	Certification of Welding Inspectors

Canadian General Standards Board (CGSB)

48.9712-2006 Non-destructive Testing, Qualification and Certification of Personnel

ASTM International

A 252-98(2007) Welded and Seamless Steel Pipe Piles
A 328/A 328M-07 Steel Sheet Piling
D 1143/ D 1143M-07 Standard Test Methods for Deep Foundations Under Static Axial Compressive Load
D 3689-07 Standard Test Methods for Deep Foundations Under Static Axial Tensile Load
D 3966-07 Standard Test Method for Deep Foundations Under Lateral Loads

American Petroleum Institute (API)

API 13A Drilling Fluid Materials, 17th Edition, 10.00.08
RP 13B-1 Standard Procedure for Field Testing Water Based Drilling Fluids, 4th Edition,

Steel Structures Painting Council (SSPC)

SP10/NACE No.2-Jan. 1, 2001 Near-White Blast Cleaning

International Organization for Standardization/International Electrotechnical Commission (ISO/IEC)

17025 General Requirements for the Competence of the Testing and Calibration Laboratories

903.03

DEFINITIONS

For the purpose of this specification, the following definitions apply:

Anvil means the component of a diesel hammer that acts as an impact block for the ram

Bedrock means a natural solid bed of the hard, stable, cemented part of the earth's crust, igneous, metamorphic, or sedimentary in origin that may or may not be weathered.

Caisson Pile means a cast in place deep foundation unit with or without an enclosing liner formed by placing concrete in a bored or excavated hole.

Cap Block means a material placed on top of the helmet to cushion the blow of the hammer and to attenuate the peak impact energy without causing excessive loss of the impact energy.

Casing means open ended enclosing cylindrical steel tubing or pipe permanently installed in the ground. Casings are structurally required and can be used to stabilize and excavated hole.

Certificate of Conformance means a document issued by the Quality Verification Engineer confirming that the specified components of the Work are in general conformance with the requirements of the Contract Documents.

Deep Foundation Unit means a structural member, driven or otherwise, installed in the ground to transfer the loads from a structure to soil or rock and derives supporting resistance from the surrounding soil or rock or from the soil or rock strata below its tip or a combination of both.

Displacement Caisson Pile means a pile formed in the ground by driving a casing or liner with a concrete plug or an expendable metal plate attached to it and replacing the displaced soil with unreinforced or reinforced concrete.

Driven Pile means one of the following pile types: steel H, tube, or sheet piles; wooden pile; or precast reinforced concrete pile that has been installed by means of a pile driver.

Driving Shoe means reinforcement attached to the bottom of the pile and designed to protect the pile during driving or to penetrate into a hard stratum.

Driving to a Set means driving the pile to the requirement that satisfies pile driving criteria correlated to a required pile resistance.

Engineer means a professional engineer licensed by the Professional Engineers Ontario to practice in the Province of Ontario.

Follower means a removable extension that transmits the hammer blows to the head of the pile.

Helmet means a formed steel cap that fits over the top of a pile head to retain in position a resilient cap block.

Jetting means the use of a jet of water at high pressure directed into the ground below the pile tip to assist its penetration

Liner means open ended enclosing steel tubing or pipe temporarily installed in the ground to facilitate the construction of caisson piles

Pile means a relatively slender structural element that is installed, wholly or partly in the ground by driving, drilling, auguring, jetting, or other means.

Pile Cap means a footing or some other structural component used to transfer the load to the piles as well as maintaining them in position.

Pile Cushion means a pad of resilient material placed between the helmet and the top of a precast reinforced concrete or wooden pile to minimize damage to the head during driving.

Pile Group means the piles supporting a pile cap.

Pumped Concrete means a method of transporting concrete through hose or pipe by means of positive and continuous pressure.

Quality Verification Engineer (QVE) means an Engineer retained by the Contractor qualified to provide the services specified in the Contract Documents.

Ram means the moving or driving part of an air, steam, diesel, or drop pile hammer that delivers an impact blow to an anvil and to the pile.

Retapping means verifying that the specified resistance previously attained has been sustained by imparting appropriate hammer energy to the pile and monitoring pile penetration.

Rock Points means a specially designed steel tip fitted to piles to enable them to be driven into hard, sound sloped bedrock.

Sheet Pile means a pile that is designed to interlock with adjacent piles and form a continuous wall for the purpose of resisting mainly lateral forces and to reduce seepage.

Slurry means a drilling fluid, consisting of water mixed with one or more of various solids or polymers, used to maintain the stability of the side walls and bottom of an excavation.

Tremie means a hopper with a vertical pipe used for placing concrete under water. The foot of the pipe is always submerged in concrete except during commencement of concreting and the upper level of the concrete in the pipe is always above water level.

903.04 DESIGN AND SUBMISSION REQUIREMENTS

903.04.01 Design Requirements

903.04.01.01 Concrete

The Contractor is responsible for providing plastic concrete with suitable characteristics for installation. The concrete shall be flow able, non-segregating concrete that does not exhibit rapid slump loss.

903.04.02 Submission Requirements

903.04.02.01 General

All submissions shall bear the seal and signature of an Engineer experienced in the field of deep foundations.

When welded field splices are used, welding procedures according to the Canadian Welding Bureau shall be submitted to the Contract Administrator.

903.04.02.02 Preconstruction Survey

A condition survey of property and structures that may be affected by the work shall be submitted to the Contract Administrator prior to commencing the work. The survey shall include the locations and conditions of adjacent properties; buildings; underground structures; Utility services; and structures, such as walls abutting the site.

903.04.02.03 Materials

903.04.02.03.01 Mill Certificates

One copy of the mill certificates, indicating that the steel meets the requirements for the appropriate standards for H-piles, tube piles, casings, and sheet piles shall be submitted to the Contract Administrator at the time of delivery.

Where mill test certificates originate from a mill outside Canada or the United States of America, the information on the mill certificates shall be verified by testing by a Canadian laboratory. The laboratory shall be certified by an organization accredited by the Standards Council of Canada to comply with the requirements of ISO/IEC 17025 for the specific tests or type of tests required by the material standard specified on the mill test certificate. The mill test certificates shall be stamped with the name of the Canadian testing laboratory and appropriate wording stating that the material conforms to the specified material requirements. The stamp shall include the appropriate material specification number, the date (i.e., yyyy-mm-dd), and the signature of an authorized officer of the Canadian testing laboratory.

903.04.02.03.02 Concrete

A suitable, site-specific concrete mix design that meets the requirements of the hardened concrete shall be submitted to the Contract Administrator 14 Days prior to construction, for information purposes only.

903.04.02.03.03 Slurry

The following shall be submitted to the Contract Administrator 14 Days prior to construction, for information purposes only:

- a) The type, source, and physical and chemical properties of the bentonite or polymer.
- b) The source of water.
- c) Method of mixing slurry.
- d) The water solids ratio and the mass and volumes of the constituent parts, including any chemical admixtures or physical treatment employed to produce slurry with the required physical properties.
- e) Details of procedure to be used for monitoring the quality of the slurry.
- f) A test report showing the properties of the slurry and certifying that the slurry meets the requirements of API RP 13B-1.
- g) Method of disposal of the slurry.

903.04.02.04 Installation

903.04.02.04.01 Driven Piles

The following shall be submitted to the Contract Administrator as least 14 Days prior to construction, for information purposes only:

- a) A schedule of work identifying time and sequence of activities.
- b) Type of equipment, anvil, helmet, and hammer details, including the hammer energy assumed by the Contractor, stated potential energy (rated energy) of the hammer, operating efficiency, and weight of ram.
- c) Working Drawings of precast concrete piles showing the pile dimensions, concrete strength, tendon arrangement, working stresses and arrangement of steel reinforcement, schedules, elongation calculations, method and sequence of casting, complete specifications and details of the prestressing steel, and lift anchors and lifting point locations.
- d) The method of maintaining the steel reinforcement cages in position, when steel reinforcement cages are used in tube piles.
- e) Procedure for monitoring pile installation.
- f) Details of the method of attaching proprietary driving shoes.
- g) When load testing is specified in the Contract Documents, details of the full-scale test, including site preparation and the details of the load application, components, equipment, testing apparatus, and method of monitoring.
- h) Information pertinent to establishing the resistance of a pile when the wave equation analysis method is used.

903.04.02.04.02 Caisson Piles

The following shall be submitted to the Contract Administrator at least 14 Days prior to construction, for information purposes only:

- a) A schedule of work identifying time and sequence of activities.
- b) Detailed procedures for caisson excavation in overburden and rock.

- c) Detailed procedures for casing and liner installation and for the withdrawal of the liner.
- d) Detailed procedures for slurry displacement method of excavation, including disposal of slurry upon completion.
- e) Detailed procedures for tremie concrete, including the size of tremie delivery pipe.
- f) Detailed procedure for placing concrete in the dry.
- g) Method of maintaining the steel reinforcement cages in position in the caisson.
- h) Details of filling the annular void around a casing.
- i) Details of procedure to be used for monitoring installation.
- j) When load testing is specified in the Contract Documents, details of the full-scale test, including site preparation, details of the load application, components, equipment, testing apparatus, and method of monitoring.

903.04.02.04.02.01 Milestone Inspections

The Quality Verification Engineer shall witness the following interim inspections of the work for caisson piles:

- a) Excavation
- b) Steel reinforcement installation
- c) Placing of concrete

A copy of the written permission to proceed shall be submitted to the Contract Administrator prior to commencement of the next operation.

903.04.02.04.03 Displacement Caisson Piles

The following shall be submitted to the Contract Administrator as least 14 Days prior to construction, for information purposes only:

- a) A schedule of work identifying time and sequence of activities.
- b) Type of equipment, anvil, helmet, and hammer details, including the hammer energy assumed by the Contractor, stated potential energy (rated energy) of the hammer, operating efficiency, maximum stroke or drop, and weight of the ram.
- c) Details of procedures used for installation of displacement caisson piles, including detailed procedures for liner installation and withdrawal.
- d) Method of maintaining the steel reinforcement cages in position in the pile.
- e) Details of procedure to be used for monitoring pile installation.
- f) When load testing is specified in the Contract Documents, details of the full-scale test, including site preparation, and the details of the load application, components, equipment, testing apparatus, and method of monitoring.

903.04.02.04.04 Steel Reinforcement Cages

Working Drawings showing the fabrication details of the steel reinforcement cages, including the lifting points and lifting lugs, shall be submitted to the Contract Administrator at least 14 days prior to fabrication, for information purposes only.

903.04.02.05 Qualifications

Copies of the Canadian Welding Bureau's certification of the Independent Testing Company, the Non-destructive Testing Technician, and the Welding Inspector shall be submitted to the Contract Administrator at least 5 Days prior to the commencement of any non-destructive testing, for information purposes only.

903.04.02.06 Review of Splice Test Results and Permission to Proceed

Upon completion of the testing of the splices, the Quality Verification Engineer shall review all test results to verify that all the welds were done according to the welding procedures and Contract Documents and issue the Contractor written permission to proceed with the work.

903.05 MATERIALS

903.05.01 Wooden Piles

Wooden piles shall be according to CAN3-056 and shall be clean and peeled. Treated piles shall be pressure treated with creosote according to CAN/CSA-080.

Wooden piles shall be provided with collars sufficiently strong to prevent splitting of the head of the wooden pile during driving.

903.05.02 Steel Piles

903.05.02.01 H-Piles

Steel H-piles shall be according to CAN/CSA G40.20/G40.21, Grade 350 W.

903.05.02.02 Tube Piles

Steel tube piles shall be according to ASTM A 252, minimum Grade 2.

903.05.02.03 Sheet Piles

Steel sheet piles shall be according to ASTM A 328M.

903.05.02.04 Straightness Tolerance for Steel Piles, Casings, and Liners

Steel piles, casings, and liners shall conform to a straightness tolerance of 1.5 mm maximum per metre of length.

Steel sheet piles shall be sufficiently straight to prevent binding in the interlock during driving.

903.05.03 Driving Shoes and Rock Points

Rock points and driving shoes shall be as specified in the Contract Documents.

Driving shoes shall transfer the driving stresses to the pile over the full cross-sectional area of the pile.

Where precast concrete piles are driven into dense or hard material, a steel driving shoe cast into the concrete shall be provided.

Where wooden piles are driven into dense material, a steel plate driving shoe shall be provided to prevent damage to the bottom of the pile.

903.05.04 Casing for Caissons

Casings shall be according to ASTM A 252, Grade 2. If welded, they shall be welded by the electric arc method according to CSA W59.

The casing wall thickness specified is the minimum that shall be supplied. The wall thickness shall be increased as required to ensure the casing is not damaged during handling and installation.

903.05.05 Steel Reinforcement

Steel reinforcement shall be according to OPSS 1440.

903.05.06 Concrete

903.05.06.01 General

Concrete shall be according to OPSS 1350.

903.05.06.02 Tube Piles

Concrete shall have a slump of 150 to 180 mm.

903.05.06.03 Caisson Piles

Concrete shall have a slump of 150 to 180 mm. When approved by the Contract Administrator in writing, admixtures may be used. Where the liner is to be withdrawn, sufficient retarder shall be added to prevent arching of concrete during liner withdrawal and to prevent setting of concrete until after the liner is withdrawn.

903.05.07 Precast Concrete Piles

The production of precast reinforced concrete piles shall be according to OPSS 904, OPSS 905, and OPSS 909.

Steel reinforcement shall be placed such that direct loading during the ram stroke shall not occur.

Lifting anchors shall be at least 25 mm clear from reinforcement or prestressing steel in the pile.

Concrete in precast reinforced concrete piles shall be according to OPSS 1350 and have a nominal minimum 28-Day compressive strength of 45 MPa.

Concrete for precast reinforced concrete piles shall be cured according to OPSS 904.

Concrete for precast reinforced concrete piles shall be placed in smooth mortar-tight forms that are supported to prevent excessive deformation or settlement during placing or curing.

Unformed surfaces shall be finished smooth.

When removed from the form, the pile shall present true, smooth, even surfaces free from honeycombs and voids. The pile shall be straight so that a line stretched from butt to tip on any face shall not be more than 25 mm from the face of the pile at any point.

Each precast reinforced concrete pile shall have the date of manufacture (i.e., yyyy-mm-dd) inscribed on it.

903.05.08 Slurry

903.05.08.01 Solids

Bentonite and polymers shall be according to API Spec 13A.

903.05.08.02 Water

Water shall be according to OPSS 1302.

903.05.08.03 Slurry Composition

The slurry shall consist of a stable colloidal suspension of pulverized solids or polymers thoroughly mixed with water. The density, viscosity, sand content, and pH of the slurry being used during excavation shall be according to API RP 13B-1.

903.06 EQUIPMENT

903.06.01 Hammers

Hammers shall be capable of installing the piles, casings, and liners to the depth or resistance specified in the Contract Documents, without damage to the portions that are not cut off.

The hammer used to chisel the rock point into the rock shall be capable of delivering a controlled blow in 10% increments ranging in energy from zero to the maximum hammer energy.

For precast reinforced concrete piles, the heaviest hammer practicable shall be employed and the stroke limited so as not to damage the piles. When choosing the size of the hammer, consideration shall be given to whether the pile is to be driven to a resistance or to a given depth.

903.06.02 Helmets and Striker Plates

The head of steel piles shall be protected by a striker plate or a helmet. Helmets shall have adequate and suitable cushioning material. Helmets and striker plates shall distribute the blow of the hammer evenly throughout the cross-section of the pile head.

903.06.03 Leads

Pile driver leads shall be built to afford freedom of movement for the hammer and shall be held in position at the top and bottom by guys, stiff braces, or other approved means to ensure support of the pile, casing, or liner while it is being driven. Swinging leads shall not be permitted.

Batter piles, casings, or liners shall be driven with leads aligned parallel to the axis of the pile, casing, or liner. The leads shall be equipped with a fixed, rigid, adjustable kicker.

903.06.04 Followers

When use of followers are specified in the Contract Documents, followers shall be of type, size, shape, length, and weight as to permit driving the pile, casing, or liner at the location and to the required depth or ultimate resistance specified in the Contract Documents. The follower shall be provided with a socket or hood carefully fitted to the top of the pile, casing, or liner to minimize loss of energy and to prevent damage to the pile, casing, or liner, and shall have sufficient rigidity to prevent "whip" during driving.

When followers are permitted, an identical follower shall be used when the set is being determined.

903.07 CONSTRUCTION

903.07.01 Transporting, Storing, and Handling Piles, Casings, Liners, and Reinforcing Steel Reinforcement Cages

903.07.01.01 General

Piles, casings, liners, and steel reinforcement shall be transported, stored, and handled in such a manner that damage is prevented and the strength of the components is not affected by deterioration or deformation.

Components shall be lifted and placed using appropriate lifting equipment, temporary bracing, guys, or stiffening devices so that the components are at no time overloaded, unstable, or unsafe.

Material shall be supported to prevent unequal settlement when stacked.

903.07.01.02 Wooden Piles

Canthooks, dogs, pile pulls, or use of other lifting methods that might damage the integrity of the pressure treated surface shall not be used. Cuts or breaks in the surface of treated piling shall be given three brush coats of hot creosote oil. Bolt holes shall be treated with three applications of hot creosote oil applied with a bolt hole treater.

903.07.01.03 Handling Holes in Steel Piles

Unless otherwise approved by the Contract Administrator, holes shall only be made in the portion of the pile to be cut off or in the portion of the pile to be encased in concrete.

When other holes are approved to be cut in a pile they shall be covered by splice plates placed on both sides of the section. The thickness and the mechanical properties of the plate material shall be at least equivalent to the pile material.

903.07.01.04 Precast Reinforced Concrete Piles

Precast concrete piles shall be handled only from the designated lifting points.

When lifting or transporting precast reinforced concrete piles lift anchors, slings, or other approved means shall be used. Care shall be taken when lifting and transporting to avoid any overstressing of the pile or cracking of the concrete.

Precast reinforced concrete piles shall be so handled to avoid breaking or chipping their edges.

Lift anchors shall be removed and the holes filled with a non-shrink grout or epoxy installed according to the manufacturer's recommendations.

903.07.01.05 Caisson Casings and Liners

Casings and liners shall be handled and stored in such a manner to avoid damage or distortion to them. The casings and liners shall be maintained circular within $\pm 2\%$ of the casing or liner diameter.

903.07.02 Driven Piles

903.07.02.01**Pile Driving Requirements and Restrictions**

Piles shall not be driven until embankment work or excavation work has been completed to the underside of the footing. When driving of the piles is completed, all material between the piles shall be removed to the correct elevation and any holes or voids created shall be filled to the correct elevation with compacted material approved by the Contract Administrator.

Piles shall be installed at the locations specified in the Contract Documents and to the set or depth specified without being damaged. Damage to the pile, casing, or liner during driving shall be prevented by limiting the drop or energy and number of blows of the hammer. The hammer, helmet, cap block, striker plate, and pile shall be coaxial and shall sit squarely upon each other.

A shorter stroke shall be used and proper precaution shall be taken when there is a danger of damaging or over driving the piles, casing, or liners under conditions such as:

- a) In the early stages of driving a long pile where a hard layer near the ground surface has to be penetrated.
- b) Where there is very soft material of a considerable depth and a large penetration is achieved at each hammer blow.
- c) Where it is anticipated the pile shall meet refusal on rock or other impenetrable soil.
- d) When piles are driven onto sloping bedrock.

Damage to adjacent structures, Utilities, and fresh concrete shall be prevented during pile installation. Piles shall not be driven within a radius of 8 m of concrete that has been in place for less than 72 hours. Piles shall not be driven within a radius of 15 m of concrete that has been in place for less than 72 hours without the approval of the Contract Administrator.

The tops of all piles shall be either square to the longitudinal axis of the pile or horizontal as indicated in the Contract Documents.

Piles shall not be forced into their proper position by the use of excessive manipulation. Pile damage due to excessive driving shall be avoided.

903.07.02.02**Driving Shoes and Rock Points**

Driving shoes and rock points shall be installed in locations specified in the Contract Documents.

Driving shoes shall be welded in accordance with the Contract Documents.

When driving shoes are specified in the Contract Documents, the Titus H bearing pile point or APF Hard Bite, standard model, may be substituted for the driving shoes.

When Oslo points are specified in the Contract Documents, the Titus H bearing pile point or APF, rock injector model, may be substituted for the pile points.

Where proprietary driving shoes are used, they shall be welded or otherwise attached to the driven piles according to the manufacturer's specifications.

903.07.02.03**Splicing****903.07.02.03.01****General**

Any damaged material shall be cut-off prior to splicing.

903.07.02.03.02 Wooden Piles

Wooden piles shall not be spliced.

903.07.02.03.03 H-Piles, Tube Piles, and Sheet Piles

Welding shall be according to CSA W59 and shall be done by a qualified welder employed by a firm certified according to CSA W47.1, Division 1 or Division 2.1.

Steel H-piles and steel tube piles may be spliced providing the pieces being spliced are not less than 3 m long. Splices in marine structures shall be located below the low water level, unless otherwise encased in concrete.

Sheet piles shall not be spliced without approval by the Contract Administrator.

903.07.02.03.04 Precast Reinforced Concrete Piles

Precast reinforced concrete piles shall only be spliced when specified in the Contract Documents and the splices shall only be made with approved mechanical splicing devices.

903.07.02.04 Concrete in Steel Tube Piles

Concrete in steel tube piles shall be placed according to OPSS 904.

903.07.02.05 Cutting Off Piles

903.07.02.05.01 General

Driven piles shall be cut to the elevation as specified in the Contract Documents.

The length of pile supplied shall be sufficient to ensure there is no damaged material below the cut off. Damaged material at the pile head shall be cut off.

Piles shall not be cut off until retapping, redriving, and specified load testing are complete.

903.07.02.05.02 Wooden Piles

Where wooden piles are broomed, splintered, or otherwise damaged below the cut-off elevation, the pile shall be considered defective and shall be replaced.

903.07.02.06 Protective Coating for Steel H and Steel Tube Piles

Exposed steel H and steel tube piles shall have a coal tar epoxy protective coating applied from an elevation 600 mm below the low water level or finished ground surface up to the top of the exposed steel.

The steel surfaces shall be cleaned according to SSPC-SP10 prior to application of a coal tar epoxy system that shall be according to OPSS 911.

903.07.02.07 Monitoring Driven Piles

903.07.02.07.01 General

The driving of piles shall be carefully monitored and controlled and pile driving records produced for each pile. The QVE or an individual under the direct supervision of the QVE shall verify the work.

Piles shall not be overdriven. When driving to a specified ultimate resistance, driving to a set or driving to bedrock, the piles shall be driven to the anticipated tip elevation. The Contract Administrator shall be notified if

the piles do not reach set at the anticipated tip elevation, .

In soils where there is a possibility of piles moving upward due to ground heave, elevations of completed pile tops shall be measured at intervals while nearby piles are being installed. The readings shall be recorded and submitted to the Contract Administrator as the work proceeds.

903.07.02.07.02 Driving to a Specified Elevation

Piles shall be driven to an elevation specified in the Contract Documents. Driving piles to other elevations shall only be done when approved in writing by the Contract Administrator.

903.07.02.07.03 Driving to a Specified Ultimate Resistance

903.07.02.07.03.01 General

The Quality Verification Engineer shall establish the reference set used to determine ultimate resistance and measure and record the set for individual pile acceptance.

The set and rebound measurements shall be obtained by the Quality Verification Engineer. The Quality Verification Engineer shall determine the measured ultimate resistance and verify that the design ultimate resistance has been achieved.

903.07.02.07.03.02 Driving to a Set

The founding elevation shall be established by driving to a set determined in accordance with the dynamic formula specified in the Contract Documents or by the application of the wave equation analysis procedure that verifies the pile resistance. This set shall be established on the first pile of every ten piles driven in a pile group.

The other piles shall be controlled by the pile penetration rate in blows per millimetre that correlates to the set.

When new conditions, such as change in hammer size, change in pile size, or change in soil material occur, new sets shall be determined.

903.07.02.07.03.03 Driving to Bedrock

When driving piles to bedrock, the pile shall be adequately seated on bedrock without damaging the pile.

Where rock points are used, the rock points shall penetrate into the rock. Piles driven using rock points shall be driven to ensure adequate seating on the bedrock without damaging the pile.

Driving of piles on sloping bedrock shall be stopped when initial contact is made with the bedrock. The bedrock elevation shall be recorded. Driving shall then continue, commencing with energy of 10% of the maximum energy of the hammer. The pile shall be driven in sets of 20 blows at this energy until no penetration is observed. Twenty additional blows shall be applied, and, if no penetration is observed, the energy shall be increased by an additional 10% and the above procedure repeated.

Driving shall continue with these stepped increases in energy and with the same series of blows as described above, until the pile has been seated on the bedrock.

If unrealistic excessive penetration per blow is observed, driving shall be stopped and this excessive penetration immediately reported to the Contract Administrator.

The Quality Verification Engineer shall determine when the hammer energy can be increased and when the driving is complete for each pile.

903.07.02.07.04 Wave Equation Analysis

When requested by the Contract Administrator, all equipment, material, and personnel shall be supplied to conduct the wave equation analysis procedure. The Quality Verification Engineer shall review the results of the analysis.

903.07.02.07.05 Hammer Performance

When requested by the Contract Administrator, the hammer performance using the pile driving analyzer or other approved equivalent shall be verified in the presence of the Contract Administrator. Hammer performance shall be verified to ensure that the actual potential energy (rated energy) is not less than 90% of the stated potential energy. All instrumentation, access, and assistance for the testing and monitoring as directed by the Contract Administrator shall be provided.

903.07.02.07.06 Retapping Tests on Piles

In each pile group, 10% of the piles rounded up to the next whole number, but no fewer than two piles, shall be retapped no sooner than 24 hours after installation of the individual pile to confirm that the ultimate axial resistance has been sustained.

Retapping of piles driven to bedrock is not required.

903.07.02.07.07 Retapping and Redriving Piles

When the retapping tests indicate that the ultimate axial resistance has not been achieved on any one pile, all piles in the group shall be retapped.

Where the retapping reveals that the ultimate axial resistance of the piles has not been achieved, the piles that have not achieved the ultimate axial resistance shall be redriven to the specified resistance.

Where piles have risen, the piles shall be redriven to the original depth.

903.07.02.08 Jetting

Jetting shall be carried out in such a manner that the resistance of the piles already in place and the safety of adjacent structures shall not be impaired. Jetting shall be stopped at least 1 m above the final expected pile-tip elevation and at least 1 m above the tip elevation of any piles previously driven within 2 m of the jet. Where piles are to be end bearing on rock, jetting may be carried to the rock surface.

The driving and jetting of precast reinforced concrete piles shall not be carried out simultaneously.

903.07.03 Caisson Piles

903.07.03.01 General

Caissons shall be constructed as specified in the Contract Documents.

The final bearing elevation shall be as specified in the Contract Documents or as determined by the Contract Administrator. When permanent casings are not specified, the caisson shall be constructed in a drilled hole with or without the use of a temporary liner or slurry as determined by the Contractor.

903.07.03.02 Excavation

903.07.03.02.01 General

Sidewall stability shall be maintained throughout the excavation and concrete placement operation. Soil

cave-in into the excavation hole shall be prevented.

The bottom of the excavation shall be cleaned before the start of concrete placement.

Excavation methods shall be such that the sides and bottom of the hole are straight and free of loose material that might prevent intimate contact of the concrete with undisturbed soil or bedrock.

Except when founded on sloping rock, the caisson bottom shall be level. On sloping rock, the caisson bottom may be stepped, with each step not greater than $\frac{1}{4}$ the diameter of the bearing area.

903.07.03.02.02 Casings

When an auger is used to excavate for a casing, the diameter of the auger shall be no greater than the outside diameter of the casing.

903.07.03.02.03 Liners

The diameter of the excavation for the installation of liners shall not exceed the diameter of the liner by more than 150 mm.

903.07.03.02.04 Slurry Method

The level of slurry in the excavation shall be sufficient to prevent the intrusion of water and to maintain a stable wall with no cave-in, sloughing, or basal heave.

Slurry shall be tested as specified in API RP 13B-1. All test equipment required for the tests shall be provided. A slurry sampler capable of obtaining samples at any depth within the caisson hole shall be available at all times.

At least 1 set of tests shall be completed every 4 hours during the slurry operation. Samples shall be taken from the mud tank and from within the caisson at a depth within 300 mm of the bottom.

903.07.03.03 Inspection of the Excavation

The bottom of excavations shall be visually inspected.

903.07.03.04 Dewatering

Where dewatering is required, a dewatering scheme shall be employed in such a manner as to prevent any disturbance to the base founding material. The dewatering shall not create subsidence or cause ground loss that may adversely affect the work or adjacent structures.

903.07.03.05 Backfilling Liners Left in Place

The annular space between a liner permanently left in place and shaft excavation shall be filled with concrete or fluid grout.

903.07.03.06 Steel Reinforcement

Steel reinforcement steel shall be installed according to OPSS 905. Steel reinforcement cages shall be checked to ensure conformance to the Working Drawings prior to installation and during placement of concrete.

The steel reinforcement cage shall be fabricated in one piece.

Welding of steel reinforcement and use of splices shall not be done unless specified in the Contract

Documents.

The steel reinforcement shall not be displaced or distorted during the construction of the caisson.

903.07.03.07 Concrete

903.07.03.07.01 General

Concrete shall be placed in the caisson according to OPSS 904 and as specified herein. Concrete shall be placed immediately following interim inspection of the caisson hole by the Quality Verification Engineer.

The reinforcement shall not be displaced or distorted during the construction of the caisson.

Arching of concrete during casing withdrawal shall be prevented.

903.07.03.07.02 Concrete Placed in the Dry

The concrete may be placed free fall provided the fall is vertically down the centre of the opening and transverse ties, spacers or other objects do not impede the free fall. In the event of interference with the concrete free fall, an elephant trunk or other means shall be used to prevent concrete segregation.

Concrete shall be placed in a continuous operation from the bottom to the top of the caisson or, where columns are cast integral with the caisson, to the elevation of the bottom of the column steel reinforcement cage. The concrete shall be vibrated for the last 1.5 m of the pour.

903.07.03.07.03 Concrete Placed Under Water or Under Slurry

Tremie or pumped concrete shall be carried out in one continuous operation. The tremie or pumping operation shall be a continuous flow of concrete that prevents the inflow of water or slurry.

Where tremie concrete is to be placed in a caisson under water, the Contractor shall maintain an adequate head of water within the excavations to prevent the inflow of water through the base or walls of the caisson as the concrete is being placed.

Where tremie is placed under slurry, the caisson shall be filled with concrete entirely by tremie and the method of deposition shall not be changed part way up the caisson.

When concrete placement is not started within 6 hours of acceptance of the excavation, the excavation shall be redrilled, cleaned, and the slurry tested before concrete placement commences.

903.07.03.07.04 Withdrawal of Liners

Arching of concrete during withdrawal of the liner shall be prevented.

During withdrawal, the bottom of the liner shall have a minimum embedment into the concrete being placed and a sufficient head of concrete shall be maintained above the bottom of the liner at all times to prevent intrusion of soil and water into the hole.

During withdrawal, upward or downward movement of the steel reinforcement shall be monitored. Upward or downward movement shall be restricted to 150 mm.

A theoretical concrete level shall be calculated based on the quantity of concrete placed and the caisson dimensions, and this theoretical level shall be compared to the actual level of concrete in the caisson to provide a check for possible separation of shaft concrete during liner withdrawal.

903.07.03.07.05 Founding Elevation

The final founding elevation shall be as specified in the Contract Documents or an elevation approved in writing by the Contract Administrator. When casings are not specified in the Contract Documents, the caisson shall be constructed in a drilled hole with or without the use of a liner or slurry as determined by the Contractor.

Except when founded on sloping unweathered bedrock, the caisson bottom shall be level. On sloping unweathered bedrock, the caisson bottom may be stepped, with each step not greater than one quarter the diameter of bearing area.

The bearing area of the caisson pile shall be approved by the Quality Verification Engineer prior to placing concrete.

903.07.04 Displacement Caisson Piles

Work shall be carried out in accordance with the displacement caisson pile suppliers' installation procedures. A permanent liner shall be used when specified in the Contract Documents.

The sequence of installation shall be such as to prevent damage to any recently completed piles.

The pile shall not be founded above or below the specified pile tip elevation without approval in writing from the Contract Administrator.

The QVE or an individual under the direct supervision of the QVE shall verify the installation of displacement caisson piles.

903.07.05 Tolerances

903.07.05.01 Driven Piles

- a) Cut-off elevation ± 25 mm.
- b) Deviation from vertical not more than 1H:50V, except in the case of a pile cap or footing supporting only a single row of piles the deviation shall not be more than 1H:75V in the direction of the span.
- c) The deviation from the specified inclination for battered piles shall not exceed 1H:25V.
- d) The centre of the pile at the junction with the pile cap shall be within 150 mm measured horizontally of that specified except in the case of a pile cap or footing supported on a single row of piles the deviation shall not be more than 75 mm measured horizontally in the direction of the span.

903.07.05.02 Caissons and Displacement Caisson Piles

- a) Cut-off elevation ± 25 mm.
- b) Horizontal location at cut-off not more than 5% of shaft diameter or 75 mm, whichever is less.
- c) Vertical alignment not more than 2% of the caisson length from vertical for vertical caissons, or 2% of the caisson length from the specified inclination for battered caissons.

903.07.06 Load Test

When a load test is specified in the Contract Documents, the testing shall be according to ASTM D 1143M for piles under vertical static load, ASTM D 3689 for piles under tensile load, and ASTM D 3966 for piles under lateral loads. The Quality Verification Engineer shall witness the pile load test. All records and results of the

pile load test attached with the Certificate of Conformance shall be submitted to the Contract Administrator.

All necessary personnel, equipment, and material to make adjustments during the tests shall be provided and at least one skilled worker shall be present for the complete duration of each test. This worker shall have demonstrated experience in load testing of piles.

The following shall be provided for the duration of all testing:

- a) A level dry working area at the test location
- b) An adequate enclosure sufficient to provide complete protection from adverse weather conditions
- c) All temporary work required to obtain access to the site for the personnel, equipment, and materials.

Upon completion of the tests, the site shall be cleared and restored to the satisfaction of the Contract Administrator. Piles that are not part of the finished work shall be cut off 1.2 m below ground level or 0.6 m below stream bed level. Any resulting void shall be backfilled with suitable fill material.

903.07.07 Repair of Welds

Any section of weld that does not meet the requirements of the Contract Documents shall be removed and rewelded.

903.07.08 Quality Control

903.07.08.01 Inspection and Testing of Welds

903.07.08.01.01 Qualifications of Companies and Individuals

An independent testing company with no corporate affiliation with the Contractor shall be employed to carry out the non-destructive testing of welds. The independent testing company shall be certified by the Canadian Welding Bureau to the requirements of CSA W178.1 for bridge structures by radiographic or ultrasonic test methods.

Testing shall be done by a non-destructive testing technician employed by an independent testing company. The non-destructive testing technician shall have documented evidence of training and professional knowledge, skill, and experience in non-destructive testing of structural steel welds and material and have a valid certificate showing qualification to a Level II or III according to CAN/CGSB-48.9712 and the Canadian Welding Bureau for the non-destructive testing specified.

Visual inspections shall be performed by a welding inspector employed by an independent testing company. The welding inspector shall have documented evidence of training, professional knowledge, skill and experience in the visual inspection of structural steel welds and material, and have a valid certificate showing qualification to Level II or III according to CSA W178.2.

903.07.08.01.02 Visual Inspection of Welds

A representative sample of not less than 30% of the welds, as determined by the Quality Verification Engineer, shall be visually inspected for conformance to the requirements of CSA W59, the Contract Documents, and the Working Drawings.

903.07.08.01.03 Non-Destructive Testing of Welds

Radiographic or ultrasonic testing shall be carried out using procedures according to CSA W59.

Ultrasonic or radiographic testing shall be carried out on the entire length of selected splice welds chosen at

random by the Quality Verification Engineer or the Welding Inspector assigned to carry out visual inspection.

Selection shall be based on the following criteria:

- a) For pile groups other than at integral abutments, 10% of the splice welds, rounded to the next highest number, but no fewer than two.
- b) For pile groups at integral abutments, 10% of the splice welds, rounded to the next highest number, but no fewer than two of when the welds are below 6 m of the pile cut-off elevation.
- c) For pile groups at integral abutments, all splice welds within 6 m of the pile cut-off elevation.

903.07.08.01.04 Repaired Welds

All welds that have been repaired shall be visually inspected and shall undergo non-destructive testing.

903.07.08.02 Non-Destructive Test Reports and Visual Inspection Reports

Within 7 Days from completion of the inspection and testing, two copies of all inspection and testing reports shall be submitted to the Contract Administrator, for information purposes only.

903.07.08.03 Certificate of Conformance

A completed Certificate of Conformance shall be submitted to the Contract Administrator upon completion of the deep foundation work. The Certificate of Conformance shall be sealed and signed by the Quality Verification Engineer and shall state that the deep foundation work has been carried out in general conformance with the Contract Documents and Working Drawings. The Certificate of Conformance shall also certify that the interim milestone inspections have been completed as specified.

When the specified horizontal tolerances are not achieved, the process for "Non-Conforming Work by the Contractor" as specified elsewhere in the Contract Documents shall be followed unless the pile discrepancies are minor and do not require a detailed design evaluation.

For these minor cases, a proposal for an amendment to the Contract Documents stating that the pile discrepancies are minor and do not require detailed design evaluation shall be submitted to the Contract Administrator for acceptance.

The proposal shall be signed by an Engineer and shall be accompanied by a drawing containing the following information:

- a) Specified pile locations;
- b) Actual pile locations; and
- c) Proposed adjustments to the footing and reinforcement.

903.09 MEASUREMENT FOR PAYMENT

903.09.01 Actual Measurement

903.09.01.01 H-Piles, Tube Piles, Wooden Piles, and Precast Reinforced Concrete Piles

Measurement of piles shall be by length in metres of the piling left in place after cut-off.

903.09.01.02 Sheet Piles

Measurement of sheet piles shall be by area in square metres based on the driving lines specified and the length of piling left in place after cut-off.

903.09.01.03 Driving Shoes

For measurement purposes, a count shall be made of the number of drive shoes used.

903.09.01.04 Rock Points

For measurement purposes, a count shall be made of the number of rock points used.

903.09.01.05 Caissons and Displacement Caisson Piles

Measurement of caissons and displacement caisson piles shall be by length in metres of the depth along the centreline between the approved bearing surface at the bottom and the specified elevation at the top.

903.09.01.06 Retapping Piles

For measurement purposes, a count shall made of the number of piles retapped above and beyond the minimum number described in the Retapping Tests on Piles clause.

Piles retapped as part of the minimum number required for the retapping tests described in the Retapping Tests on Piles clause shall not be measured for payment.

903.09.02 Plan Quantity Measurement

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

903.10 BASIS FOR PAYMENT

**903.10.01 Supply Equipment for Installing Driven Piles - Item
Supply Equipment for Installing Caisson Piles - Item
Supply Equipment for Installing Displacement Caisson Piles - Item**

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material required to do the work.

For payment purposes, 50% of the work under this item is completed when the satisfactory performance of the equipment has been demonstrated to the Contract Administrator by the installation of 1% of piles. The remaining 50% shall be paid on the satisfactory completion of the installation of piles.

When the hammer performance is requested to be verified, such verification shall be completed at no extra cost to the owner when the energy delivered is less than 90% of the stated potential energy (rated energy) specified in the submission.

When the energy is equal to or greater than 90% of the stated potential energy stated in the required submission, the cost verifying the hammer performance shall be administered as a Change in the Work.

**903.10.02 H-Piles - Item
Tube Piles - Item
Precast Concrete Piles - Item
Wood Piles - Item
Displacement Caisson Piles - Item**

Caisson Piles - Item
Driving Shoes - Item
Rock Points - Item
Sheet Piles - Item
Load Test - Item

Payment at the Contract price for the above tender items shall be full compensation for all labour, Equipment, and Material to do the work.

Payment for redriving piles shall be at the Contract price for the applicable tender item above.

When the Contractor substitutes driving shoes or Oslo points with Titus H bearing pile points, the cost of such substitutions shall be at no extra cost to the Owner.

903.10.03 Retapping Piles - 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.

Retapping the minimum specified number of piles for retapping tests shall include all labour, Equipment, and Material to do the work and shall be included in the Contract price for the appropriate pile tender item.

Where additional retapping is required, payment shall be made based on the ratio of the number of piles retapped in a pile group above the minimum requirement, up to the total number of piles in that pile group, times the tender price for retapping all piles for that pile group.

Appendix 903-A, April 2016
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

No information provided here.

Related Ontario Provincial Standard Drawings

No information provided here.

