

This guide specification was prepared utilizing 3-part format recommended by the Construction Specifications Institute (CSI), and generally incorporates recommendations from their SectionFormat™/Page Format™, and MasterFormat®, latest Editions, insofar as practicable.

Carefully review and edit the text to meet the Project requirements and coordinate this Section with the remainder of the Specifications and the Drawings.

Where bracketed text is indicated, e.g. [text], make appropriate selection and delete the remainder of text within additional brackets, highlighting, and bold face type, if any.

This specification defines material and performance requirements for the "Silva Cell System". The Specifier should adapt these specifications to reflect specific project requirements.

Consult the manufacturer for assistance in editing this guide specification for specific Project applications where necessary, including conventional applications, and for assistance evaluating and sizing design elements for Silva Cell stormwater applications.

This Specification was current at the time of publication but is subject to change. Please confirm the accuracy of these specifications with the manufacturer prior to use.

Some elements in these specifications require coordination with Project drawings; these items are noted "as indicated on plans or drawings" or similar phrases.

Refer to the DeepRoot website, www.deeproot.com for additional information.



**SECTION 32 94 51
SOIL CELLS
("SILVA CELL SYSTEM")**

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Silva Cell system for planting and paving, including Silva Cell assemblies and related accessories.
 - 2. Other materials including, but not limited to, geotextile, geogrid, aggregate, subbase material, backfill, root barrier, Water + Air System, and planting soil.

SPECIFIER: Delete paragraph below if planting soils will be installed under a separate contract.

- B. Materials Installed But Not Furnished Under This Section:
 - 1. Planting soils are furnished in Section 32 94 56 - Planting Soil for Silva Cells.
- C. Related Requirements:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

SPECIFIER: Revise Section numbers and titles in subparagraphs below per CSI MasterFormat and Project requirements.

2. Section 01 33 00 - Submittal Procedures: For administrative and procedural requirements for processing of submittals during the construction phase.
3. Section 01 77 00 - Closeout Procedures: For administrative and procedural requirements for completion of the Work.

SPECIFIER: Sections listed below are examples only; revise Section numbers and titles in subparagraphs below to suit Project requirements.

4. Section 32 12 16 - Asphalt Paving
5. Section 32 13 13 - Concrete Paving
6. Section 32 14 00 - Unit Paving
7. Section 32 84 00 - Planting Irrigation
8. Section 32 93 00 - Plants

1.02 REFERENCES

A. Definitions:

1. AGGREGATE BASE COURSE: Aggregate material between the paving and the top of the Silva Cell deck below, designed to distribute loads across the top of the deck.

SPECIFIER: Delete subparagraph below if pavers are not a part of the Project.

2. AGGREGATE SETTING BED FOR PAVERS: Aggregate material between the aggregate base course and unit surface pavers, designed to act as a setting bed for the pavers.
3. AGGREGATE SUBBASE: Aggregate material between the bottom of the Silva Cell base and the compacted subgrade below, designed to distribute loads from the Silva Cell bases to the subgrade.
4. BACKFILL: The earth used to replace or the act of replacing earth in an excavation beside the Silva Cell system to the excavation extents.
5. FINISH GRADE: Elevation of finished surface of planting soil or paving.
6. PLANTING SOIL: Soil as defined in Division 32, Section 32 94 56 - Planting Soil for Silva Cells, intended to fill the Silva Cell system and other planting spaces.
7. SILVA CELL SYSTEM:
 - a. Silva Cell: One assembled unit made up of 1 base, 6 post assemblies, and 1 Silva Cell deck.
 - b. Silva Cell System: Two or more Silva Cells used in combination with each other and with all required accessories.
8. SUBGRADE: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.
9. WALK-THROUGH COMPACTION: A process for light compaction of soils by walking through the soil following placement.
 - a. Walk through compaction shall result in 75-85 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method. Do not exceed root limiting compaction for the given soil type.

B. Reference Standards:

SPECIFIER: Use care when indicating the edition date of the referenced standards; these standards are subject to regular review, and updated accordingly.

1. American Association of State Highway and Transportation Officials (AASHTO):
 - a. AASHTO H-20

2. ASTM International (ASTM):
 - a. ASTM D448-12, Standard Classification for Sizes of Aggregate for Road and Bridge Construction
 - b. ASTM D698-12e1, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ [600 kN-m/m³])
 - c. ASTM D1241-07, Standard Specification for Materials for Soil-Aggregate Subbase, Base, and Surface Courses
 - d. ASTM D3786/D3786M-13, Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
 - e. ASTM D4491-99a(2014)e1, Standard Test Methods for Water Permeability of Geotextiles by Permittivity
 - f. ASTM D4533-D4533M-15, Standard Test Method for Trapezoid Tearing Strength of Geotextiles
 - g. ASTM D4632-D4632M-15, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
 - h. ASTM D4751-12, Standard Test Method for Determining Apparent Opening Size of a Geotextile
 - i. ASTM D4833/D4833M-07(2013)e1, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products
 - j. ASTM D5262-07(2012), Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
 - k. ASTM D6241-14, Standard Test Method for Static Puncture Strength of Geotextile and Geotextile-Related Products Using a 50mm Probe
 - l. ASTM D6637-11, Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

SPECIFIER: Delete reference below if Project is not located in Canada.

3. Ontario Provincial Standard Specification (OPSS)

1.03 ADMINISTRATIVE REQUIREMENTS

SPECIFIER: Select either "Landscape Architect", "Architect" or "Engineer" in paragraph below as applicable.

- A. Preinstallation Conference: Prior to installation of the Silva Cell system and associated Work, meet with the Contractor, Silva Cell system installer and their field supervisor, manufacturer's technical representative (remotely), the **[Landscape Architect] [Architect] [Engineer]**, the Owner at the Owner's discretion, and other entities concerned with the Silva Cell system performance.
 1. Provide at least 72 hours advance notice to participants prior to convening preinstallation conference.
 2. Introduce and provide a roster of individuals in attendance with contact information.
 3. The preinstallation conference agenda will include, but is not limited to the review of:
 - a. Required submittals both completed and yet to be completed.
 - b. The sequence of installation and the construction schedule.
 - c. Coordination with other trades.
 - d. Details, materials and methods of installation.
 - 1) Review requirements for substrate conditions, and special details, if any.
 - 2) Installation layout, procedures, means and methods.
- B. Sequencing and Scheduling:
 1. General: Prior to beginning Work of this Section, prepare a detailed schedule of the Work involved for coordination with other trades.
 2. Schedule utility installations prior to beginning Work of this Section.
 3. Where possible, schedule the installation of the Silva Cell system after the area is no longer required for use by other trades and Work. Where necessary to prevent damage, protect installed system if Work must occur over or adjacent to the installed Silva Cell system.

1.04 SUBMITTALS

- A. Action Submittals: Submit in accordance with Section **[01 33 00] [other]**:

SPECIFIER: Select paragraph A above if detailed submittal requirements are specified in Division 01 and revise Section number if necessary to match that used in the Project Manual, or; select paragraph A below if Division 01 is not a part of the Project Manual; keep subparagraphs 1 through 5 with either paragraph A selected.

Select either "Landscape Architect", "Architect", or "Engineer" in the paragraph below as applicable.

- A. Action Submittals: Submit these to the **[Landscape Architect] [Architect] [Engineer]** for review and acceptance not less than 45 days prior to start of installation of materials and products specified in this Section.
1. Product Data: For each type of product, submit manufacturer's product literature with technical data sufficient to demonstrate that the product meets these specifications.
 2. Test and Evaluation Reports:
 - a. Submit results of compaction testing required by the Specifications for approval.
 - b. Include analysis of bulk materials including soils and aggregates, completed by a recognized laboratory that demonstrates that the materials meet the Specification requirements.
 3. Samples:
 - a. One full size sample of an assembled Silva Cell (copy of manufacturers brochure with images of product may be accepted in lieu of product sample).
 - b. Manufacturer's product data/specification sheet for geogrid.
 - c. Manufacturer's product data/specification sheet for geotextile.
 - d. Manufacturer's product data/specification sheet for Water+Air System components (when specified as part of the system)
 4. Manufacturer's Report: Submit Silva Cell system manufacturer's letter of review and approval of the Project, including Drawings and Specifications, Addenda, Clarifications and Modifications, and for compliance with product installation requirements.
 5. Qualification Statements:
 - a. Manufacturer:
 - 1) Submit list of completed projects demonstrating durability and longevity of in-place systems.
 - a) Include project name, location, and date of completion.

SPECIFIER: Delete subparagraph below if system is not being designed for stormwater management.

- 2) Submit list of third party approval for stormwater management projects.
- b. Installer:
 - 1) Submit documentation of the qualifications of the Silva Cell system installer and their field supervisor, sufficient to demonstrate that both meet the requirements specified in Article 1.05 QUALITY ASSURANCE.
 - 2) Submit list of completed projects of similar scope and scale demonstrating capabilities and experience.

- B. Closeout Submittals: Submit in accordance with Section **[01 33 00] [other]**:

SPECIFIER: Select paragraph B above if detailed submittal requirements are specified in Division 01 and revise Section number if necessary to match that used in the Project Manual, or; select paragraph B below if Division 01 is not a part of the Project Manual.

Select either "Landscape Architect", "Architect", or "Engineer" in the paragraph below as applicable.

- B. Closeout Submittals: Submit these to the **[Landscape Architect] [Architect] [Engineer]** at completion of installation.
 - 1. Warranty: Submit manufacturer's warranty, fully executed.

1.05 QUALITY ASSURANCE

- A. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State, and Municipal authorities having jurisdiction. Obtain necessary permits/approvals from these authorities.
- B. Manufacturer Qualifications:
 - 1. A manufacturer whose product is manufactured in an ISO/TS 16949 compliant and ISO 9001 - 2008 registered factory.
 - 2. A manufacturer with not less than 100 Silva Cell systems in-place, in the United States. Each system in use for not less than 7 years, confirming durability and longevity of the system.
 - 3. A manufacturer with documented written approval of their product for use as a stormwater treatment device by a minimum of 3 governmental jurisdictions.
 - 4. A manufacturer with an established and demonstrated utility service and repair process, including written procedure and photographs demonstrating work.
 - 5. A manufacturer with a published operating and maintenance manual
- C. Installer Qualifications: A qualified installer with not less than 5 years of successful experience installing Silva Cell systems or related products and materials, and whose work has resulted in successful installation of underground piping, chambers and vault structures, planting soils, and planter drainage systems of a similar scope and scale in dense urban areas.

SPECIFIER: Select either "Landscape Architect", "Architect" or "Engineer" in paragraphs below as applicable.

- D. Installer's Field Supervisor: A full-time supervisor employed by the installer with not less than 5 years of successful experience similar to that of the installer and present at the Project site when Work is in progress. Utilize the same field supervisor throughout the Project, unless a substitution is submitted to and approved in writing by the **[Landscape Architect] [Architect] [Engineer]**.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Silva Cell System: Protect Silva Cell system components from damage during delivery, storage and handling.
 - 1. Store components on smooth surfaces, free from dirt, mud and debris. Store under tarp to protect from sunlight when time from delivery to installation exceeds one week.
 - 2. Perform handling with equipment appropriate to the size (height) of Silva Cells and site conditions; equipment may include hand, handcart, forklifts, extension lifts, or small cranes, with care given to minimize damage to Silva Cell bases, post assemblies, decks and adjacent assembled Silva Cells.
- B. Packaged Materials: Deliver packaged materials in original, unopened containers indicating weight, certified analysis, name and address of manufacturer, and indication of conformance with State and Federal laws, if applicable. Protect materials from deterioration during delivery and while on the Project site.
 - 1. Do not deliver or place backfill, soils, or soil amendments in frozen, wet, or muddy conditions.
 - 2. Provide protection including tarps, plastic and/or matting between bulk materials and finished surfaces sufficient to protect the finish material.
 - 3. Bring planting soil to the site using equipment and methods that do not overly mix and further damage soil peds within the soil mix.
- D. Provide erosion-control measures to prevent erosion or displacement of bulk materials and discharge of soil-bearing water runoff or airborne dust to adjacent properties, water conveyance

systems, and walkways. Provide additional sediment control to retain excavated material, backfill, soil amendments and planting mix within the Project limits as needed.

1.07 FIELD CONDITIONS

- A. Existing Conditions: Do not proceed with Work when subgrades, soils and planting soils are in a wet, muddy, or frozen condition.

1.08 WARRANTY

SPECIFIER: This Warranty gives the Owner specific legal rights, and the Owner may also have other legal rights, which vary from state to state, or in Canada, from province to province. Some states do not allow the exclusion of incidental or consequential damages, so the stated limitations and exclusions may not apply.

- A. The Contractor shall warrant the Silva Cell system to be free of faults and defects in accordance with the General Conditions, except that the warranty shall be extended by manufacturer's written warranty against defects in materials and workmanship as follows:
 - 1. DeepRoot® warrants to the original purchaser of its Silva Cell™ product that such product will be free from defects in materials and workmanship, and perform to DeepRoot's written specifications for the warranted product, when installed and used as specifically provided in the product's installation guidelines for a period of 20 years from the date of purchase. This warranty does not cover wear from normal use, or damage caused by abuse, mishandling, alterations, improper installation and/or assembly, accident, misuse, or lack of reasonable care of the product. This warranty does not apply to events and conditions beyond DeepRoot's control, such as ground subsidence or settlement, earthquakes and other natural events, acts of third parties, and/or Acts of God. If this warranty is breached, DeepRoot® will provide a replacement product. Incurred costs, such as labor for removal of the original product, installation of replacement product, and the cost of incidental or other materials or expenses are not covered under this warranty.
 - 2. Deeproot® makes no other warranties, express or implied, and specifically disclaims the warranty of merchantability or fitness for a particular purpose. Deeproot® shall not be liable either in tort or in contract for any direct, incidental or consequential damages, lost profits, lost revenues, loss of use, or any breach of any express or implied warranty.

PART 2 - PRODUCTS

2.01 MANUFACTURER

- A. Acceptable Manufacturers:

USA - Head Office DeepRoot Green Infrastructure, LLC 1032 Irving Street, #614 San Francisco, CA 94122-220	DeepRoot Canada Corp. 2242 Kingsway #428 Vancouver British Columbia - V5N 5X6	DeepRoot Urban Solutions, Ltd. Suite 51 101 Clapham High Street London SW4 7TB
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- B. Substitutions: Manufacturers seeking approval of their products are required to receive prior approval 7 days prior to bid opening.

SPECIFIER: Select paragraph B below for a specification when substitutions are NOT allowed and delete the above paragraph above.

- B. No substitutions are allowed.

2.02 DESCRIPTION

SPECIFIER: The Silva Cell System is designed to support AASHTO H-20 loading (United States) CSA-S6 87.5 (Canada). The entire assembly as described in this specification is necessary in order to meet this loading performance. Alternative assemblies may void Silva Cell warranty. Contact DeepRoot Green Infrastructure, LLC for approval of alternative assemblies.

- A. The term Silva Cell shall be used to refer to a single Silva Cell.
- B. Silva Cells shall be designed for the purpose of growing healthy trees and providing stormwater management.
- C. Silva Cells shall be modular, structural systems.
- D. Each Silva Cell shall be structurally-independent from all adjacent Silva Cells for incorporating utilities and other site features as well as for future repairs.
- E. Silva Cells shall be capable of supporting loads up to and including AASHTO H-20 (United States) or CSA-S6 87.5 kN (Canada) when used in conjunction with approved pavement profiles.
- F. Silva Cells shall be open on all vertical faces and horizontal planes and shall have no interior walls or diaphragms.
- G. Silva Cells shall be capable of providing a large, contiguous, continuous volume of planting soil that does not inhibit or prevent the following:
 - 1. Placement of planting soil,
 - 2. Walk through compaction,
 - 3. Compaction testing of planting soil, once in place,
 - 4. Movement and growth of roots ,
 - 5. Movement of water within the provided soil volume, including lateral capillary movement, or
 - 6. Installation and maintenance of utilities placed within, adjacent to, or below the Silva Cell.
- H. Silva Cells shall be able capable of being filled with a variety of soil types and soils that include peds 2 inches (50 mm) or larger in diameter as is appropriate for the application, location of the installation, and tree species.

2.03 SILVA CELL MATERIALS AND ACCESSORIES

- A. Silva Cell System Components: Each "Silva Cell" soil cell module (hereafter Silva Cell or "cell") is composed of one base, 6 post assemblies, and one deck.
 - 1. Table 1 defines each Silva Cell System, including the system name, system dimensions (inches), and the number of base units, post units (post assembly), and deck units required to assemble one complete Silva Cell.

Table 1: Silva Cell System Assembled Dimensions and Components

System + System Dimensions (Inches)				Base	Post Assembly			Deck
System Name	System Height	Base + Deck Length	Base + Deck Width	Base QTY	.5x Post QTY	1x Post QTY	2x Post QTY	Deck QTY
.5x	12.9	47.25	23.6	1	6			1
1x	16.7	47.25	23.6	1		6		1

1.5x	21.0	47.25	23.6	1	6	6		1
2x	30.9	47.25	23.6	1			6	1
2.5x	35.1	47.25	23.6	1	6		6	1
3x	43.0	47.25	23.6	1		6	6	1
3.5x	47.3	47.25	23.6	1	6	6	6	1
4x	57.2	47.25	23.6	1			12	1

- B. Silva Cell Materials and Fabrication:
1. Bases and Posts: Homopolymer polypropylene.
 2. Decks: Fiberglass reinforced, chemically-coupled, impact modified polypropylene.
- C. Manufacturer's Related Silva Cell Installation Accessories:
1. Strongbacks: An accessory designed to stabilize the Silva Cell posts temporarily, during soil placement, and removed for reuse prior to placing decks.
 2. Anchoring Spikes: 10" landscape spike for securing assembled Silva Cells to subbase.

2.04 RELATED PRODUCTS

- A. Root Barrier: Recyclable, black, injection molded panels manufactured with a minimum 50 percent post-consumer recycled polypropylene plastic with UV inhibitors, and integrated zipper joining system which allows instant assembly by sliding one panel into another; for redirecting tree roots down and away from hardscapes.
1. Panel Sizes:
 - a. No. UB12-2: 24 inches long by 12 inches deep by 0.080 inches thick (61 cm long by 30 cm deep by 2.03 mm thick); for use with 1x systems and for pavement profiles less than 12 inches (30 cm) deep.
 - b. No. UB18-2: 24 inches long by 18 inches deep by 0.080 inches thick (61 cm long by 46 cm deep by 2.03 mm thick); for use with 2x and 3x systems, and for pavement profiles 12 inches or more in depth.
 2. Products meeting this specification:
 - a. DeepRoot Tree Root Barrier (DeepRoot Green Infrastructure, LLC)

SPECIFIER: Select one or more of the Water+Air System assemblies specified below as applicable to your Project design.

- B. Water+Air System: Used as a standalone system or in conjunction with the Silva Cell, the Water+Air System enables water and air to be directly added to tree roots and the surrounding soil system.

- [1. **Water+Air System 01:**
- a. Cast aluminum body
 - b. Stainless steel grate
 - c. Height -3 ¾" (85mm)
 - d. Compatible with 3" and 4" (80mm and 100mm) pipe
- [2. **Water+Air System 02:**
- a. Cast aluminum body
 - b. Stainless steel grate
 - c. Threaded for adjustable height
 - d. Height- adjustable 3 ½" (89mm) – 10 ½" (267mm)
 - e. Compatible with 3" and 4" (80mm and 100mm) diameter pipe

SPECIFIER: The Following pipe is an optional component of Water+Air System 01 and 02 assemblies specified above.

- [f. **Pipe**
1. High density polyethylene corrugated pipe

2. **Compliant with ASTM F405 and F667, SCS 606 and AASHTO M252**
3. **Knife cut perforations**

[3. Water+Air System (Root Ball)

- a. **3" diameter pipe (length per size of tree opening), compatible tee, flexible transition, and heavy-duty plastic grate**
4. Products meeting this specification:
 - a. DeepRoot Water+Air System (DeepRoot Green Infrastructure, LLC)

SPECIFIER: The following products may be provided by DeepRoot Green Infrastructure, LLC, or by other sources.

- B. Geogrid: Net-shaped woven polyester fabric with PVC coating, uniaxial or biaxial geogrid, inert to biological degradation, resistant to naturally occurring chemicals, alkalis, and acids; used to provide a stabilizing force within soil structure as the fill interlocks with the grid.
 1. Tensile strength at ultimate (ASTM D6637):
 - a. 1850 lbs/ft (27.0 kN/m) minimum
 2. Creep reduced strength (ASTM D5262):
 - a. 1000 lbs/ft (14.6 kN/m) minimum
 3. Long term allowable design load (GRI GG-4):
 - a. 950 lbs/ft (13.9 kN/m) minimum
 4. Grid aperture size (MD):
 - a. 0.8 inch (20 mm) minimum
 5. Grid aperture size (CD):
 - a. 1.28 inch (32 mm) maximum
 6. Roll size: 6-foot (1.8-m) width is preferred, up to 18-foot (5.4-m).
 7. Products meeting this specification:
 - a. Stratagrid SG 150; <http://www.geogrid.com>
 - b. Miragrid 2XT; <http://www.tencate.com>
 - c. Fortrac 35 Geogrid; (<http://www.hueskerinc.com>
 - d. SF 20 Biaxial Geogrid; <http://www.synteen.com>
- C. Geotextile: composed of high tenacity polypropylene yarns which are woven into a network such that the yarns retain their relative position and is inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids.
 1. Tensile strength at ultimate (ASTM D4595):
 - a. 4800 lbs/ft (70.0 KN/m) MD minimum
 - b. 4800 lbs/ft (70.0 KN/m) CD minimum
 2. Tensile strength at 5% strain (ASTM D4595)
 - a. 2400 lbs/ft (35.0 KN/m) MD minimum
 - b. 2700 lbs/ft (43.8 KN/m) CD minimum
 3. Flow rate (ASTM D4491):
 - a. 30 gal/min/ft² (2648 l/min/m²) minimum
 4. Apparent opening size (ASTM D4751):
 - a. 30 sieve (0.60 mm)
 5. UV Resistance (at 500 hours):
 - a. 80 percent strength retained
 6. Products meeting this specification:
 - a. Mirafi HP570; <http://www.tencate.com>
 - b. Geolon PP40; <http://www.tencate.com>
 - c. Nilex Woven 2044 (Nilex); <http://www.nilex.com>
- D. Plastic Cable Ties: A tensioning device or tool used to tie similar or different materials together with a specific degree of tension.

2.05 OTHER RELATED MATERIALS

- A. Wood Blocking: Nominal dimensioned untreated lumber used for spacing assembled Silva Cells.
- B. Drain and Distribution Pipes:

SPECIFIER: Consult with Project Engineer for proper selection and add information below or refer to their Specification Section.

- 1. **[Insert applicable drain pipe selection] [Refer to Section 32 84 00] [insert other Section title]**

- C. Aggregate Subbase (Below Silva Cell Base):
 - 1. Aggregate meeting one of the following specifications:

SPECIFIER: Consult with Project Engineer for proper selection and edit accordingly.

- a. Complying ASTM D1241, Type I, Gradation B; Type I mixtures shall consist of stone, gravel, or slag with natural or crushed sand and fine mineral particles passing a No. 200 sieve.

<u>Sieve</u>	<u>Percent Passing</u>
1-1/2 inches (37.5 mm)	100
1 inch (25 mm)	75 to 95
3/8 inch (9.5 mm)	40 to 75
No 4 (4.75 mm)	30 to 60
No 10 (2 mm)	20 to 45
No 40 (425 µm)	15 to 30
No 200 (75 µm)	5 to 15

- b. Local Department of Transportation (DOT) virgin aggregate that most closely meets the gradation of ASTM D1241.
- c. Ontario Provincial Standard Specification (OPSS) 1010 Granular A. Dense graded aggregates intended for use as granular base within the pavement structure, granular shouldering, and backfill.

<u>Sieve</u>	<u>Percent Passing</u>
26.5 mm	100
19 mm	85 to 100
13.2 mm	65 to 90
9.5 mm	50 to 73
4.75 mm	35 to 55
1.18 mm	15 to 40
300 µm	5 to 22
75 µm	2 to 8

- D. Aggregate Base Course (Above Silva Cell Deck):
 - 1. Same as aggregate subbase specified above.
- E. Aggregate Base Course for Porous Pavement (Above Silva Cell Deck):
 - 1. Aggregate complying with ASTM D448, No. 57.

<u>Sieve</u>	<u>Percent Passing</u>
1-1/2 inch (37.5 mm)	100
1 inch (25 mm)	95 to 100
1/2 inch (12.5 mm)	25 to 60
No 4 (4.75 mm)	0 to 10
No 8 (2.36 mm)	0 to 5

- F. Setting Bed for Unit Pavers (Above Silva Cell Deck):
 - 1. Aggregate complying with ASTM D448, No. 8.

<u>Sieve</u>	<u>Percent Passing</u>
1/2 inch (12.5 mm)	100
3/8 inch (9.5 mm)	85 to 100
No 4 (4.75 mm)	10 to 30
No 8 (2.36 mm)	0 to 10
No 16 (1.18 mm)	0 to 5

- G. Backfill Material (Adjacent to Silva Cells): Clean, compactable, coarse grained fill soil free of organic material, trash and other debris, and free of toxic material injurious to plant growth.
- H. Planting Soil: Refer to Section 32 94 56 - Planting Soil for Silva Cells.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine the conditions under which the Silva Cells are to be installed.
 - 1. Carefully check and verify dimensions, quantities, and grade elevations.
 - 2. Carefully examine the Drawings to become familiar with the existing underground conditions before digging. Verify the location of aboveground and underground utility lines, infrastructure, other improvements, and existing trees, shrubs, and plants to remain including their root system.

SPECIFIER: Select either "Landscape Architect", "Architect", or "Engineer" in the subparagraph below as applicable.

- 3. Notify the Contractor and the [**Landscape Architect**] [**Architect**] [**Engineer**] in writing in the event of conflict between existing and new improvements, of discrepancies, and other conditions detrimental to proper and timely completion of the installation.
- 4. Obtain written approval of changes to the Work prior to proceeding. Proceed with installation only after changes have been made and unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Take proper precautions as necessary to avoid damage to existing improvements and plantings.
- B. Prior to the start of Work, layout and stake the limits of excavation and horizontal and vertical control points sufficient to install the complete Silva Cell system.
- C. Coordinate installation with other trades that may impact the completion of the Work.

3.03 TEMPORARY PROTECTION

- A. Protect open excavations and Silva Cell system from access and damage both when Work is in progress and following completion, with highly visible construction tape, fencing, or other means until related construction is complete.
- B. Do not drive vehicles or operate equipment over the Silva Cell system until the final surface material has been installed.

3.04 EXCAVATION

- A. General: Excavate to the depths and shapes indicated on the Drawings. Provide smooth and level excavation base free of lumps and debris.
- B. Confirm that the depth of the excavation is accurate and includes the full section of materials required to place the subbase aggregate, Silva Cells, and pavement profile as indicated on the Drawings.
- C. Over-excavate beyond the perimeter of the Silva Cell to allow for:
 - 1. The extension of aggregate subbase beyond the Silva Cell layout as shown on the Drawings.
 - 2. Adequate space for proper compaction of backfill around the Silva Cell system.

- D. If unsuitable subgrade soils are encountered, consult the Owner's geotechnical consultants for directions on how to proceed.

SPECIFIER: Select either "Landscape Architect", "Architect", or "Engineer" in the paragraph below as applicable.

- E. If conflicts arise during excavation, notify the [Landscape Architect] [Architect] [Engineer] in writing and make recommendations for action. Proceed with Work only when action is approved in writing.

3.05 SUBGRADE COMPACTION

- A. Compact subgrade with a minimum of 3 passes with a vibratory plate compactor; or as directed by the project geotechnical consultant.
- B. Do not exceed 10 percent slope for subgrade profile in any one direction. If the 10 percent slope is exceeded, contact manufacturer's representative for directions on how to proceed.

3.06 INSTALLATION OF GEOTEXTILE OVER SUBGRADE

- A. Install geotextile over compacted subgrade.
 - 1. Lay geotextile flat with no folds or creases.
 - 2. Install the geotextile with a minimum joint overlap of 18 inches (450 mm).

3.07 INSTALLATION OF AGGREGATE SUBBASE BELOW SILVA CELL BASES

- A. Install aggregate subbase to the depths indicated on the Drawings.
- B. Extend subbase aggregate a minimum of 6 inches (150 mm) beyond the base of the Silva Cell layout.
- C. Compact aggregate subbase to a minimum of 95 percent of maximum dry density at optimum moisture content in accordance with ASTM D698, Standard Proctor Method.
- D. Do not exceed 10 percent slope on the surface of the subbase. Where proposed grades are greater than 10 percent, step the Silva Cells to maintain proper relation to the finished grade.

3.08 INSTALLATION OF SILVA CELL BASE

- A. Install the Silva Cell system in strict accordance with manufacturer's instructions and as specified herein; where requirements conflict or are contradictory, follow the more stringent requirements.
- B. Layout and Elevation Control:
 - 1. Provide layout and elevation control during installation of the Silva Cell system to ensure that layout and elevations are in accordance with the Drawings.
- C. Establish the location of the tree openings in accordance with the Drawings. Once the trees are located, mark the inside dimensions of the tree openings on the prepared subbase.
- D. Locate and mark other Project features located within the Silva Cell layout (e.g. light pole bases, utility pipes). Apply marking to identify the extent of the Silva Cell layout around these features. Follow the layout as shown on the Drawings to ensure proper spacing of the Silva Cell bases. Refer to the Drawings for offsets between these features and the Silva Cells.
- E. Check each Silva Cell component for damage prior to placement. Reject cracked or chipped units.

SPECIFIER: Select either "Landscape Architect", "Architect", or "Engineer" in the paragraph below as applicable.

- F. Place the Silva Cell bases on the compacted aggregate subbase. Start at the tree opening and place Silva Cell bases around the tree openings as shown on the Drawings.
- G. Working from tree opening to tree opening, place Silva Cell bases to fill in the area between tree openings.

1. Maintain spacing no less than 1 inch (25 mm) and no more than 6 inches (150 mm) apart, assuming geotextile covering the decks meets the specifications in section 2.04 paragraph C.

SPECIFIER: Select either "Landscape Architect", "Architect", or "Engineer" in the paragraph below as applicable.

- H. Follow the Silva Cell layout plan as shown on the Drawings.
- I. Install Silva Cell bases around, over, or under existing or proposed utility lines, as indicated on the Drawings.
- J. Level each Silva Cell base as needed to provide full contact with subbase. Adjust subbase material, including larger pieces of aggregate, so each base sits solidly on the surface of the subbase. Silva Cell bases that rock or bend over any stone or other obstruction protruding above the surface of the subbase material are not allowed. Silva Cell bases which bend into dips in the subbase material are not allowed. The maximum tolerance for deviations in the plane of the subbase material under the bottom of the horizontal beams of each Silva Cell base is 1/4 inch in 4 feet (6 mm in 1200 mm).
- K. Anchor Silva Cell base with 2 anchoring spikes per base.
 1. For applications where Silva Cells are installed over waterproofed structures, use wood blocking or similar spacing system consistent with requirements of the waterproofing system to maintain required spacing.

3.09 INSTALLATION OF SILVA CELL POST ASSEMBLIES

- A. Silva Cell Post Assembly:
 1. Attach posts to the installed Silva Cell base in the order shown in Table 2. Each base will receive 6 primary posts. Place the end of the primary post with tabs into the base. Rotate primary post clockwise to snap in place.
 2. Where post extensions are required to meet system height, install one layer of post extension at a time. Each post assembly will receive 6 post extensions per layer. Place the end of the post extension with tabs into the primary post or post extension. Rotate post extension clockwise to snap in place.
 3. Place all required strongbacks, geogrid, backfill, and planting soil for each layer of required post assembly, as described herein, before adding subsequent post extensions or decks.

Table 2: Silva Cell Post Assemblies (Name, Quantity, and Installation Order)

Post Assembly Installation Order and Quantity per Silva Cell			
Post Assembly Name	Primary Post	Post Extension 1	Post Extension 2
.5x	.5x - 6 Each		
1x	1x - 6 Each		
1.5x	1x - 6 Each	.5x - 6 Each	
2x	2x - 6 Each		
2.5x	2x - 6 Each	.5x - 6 Each	
3x	2x - 6 Each	1x - 6 Each	
3.5x	2x - 6 Each	.5x - 6 Each	1x - 6 Each
4x	2x - 6 Each	2x - 6 Each	

3.10 INSTALLATION OF STRONGBACKS, GEOGRID, BACKFILL AND PLANTING SOIL

SPECIFIER: Delete the first paragraph below if there are no drain lines within the system.

- A. For Silva Cell systems that have a perforated drain line located inside or adjacent to the system, consult Drawings for layout and details for requirements.
- B. Following the placement of primary posts, place strongbacks by snapping into place over installed posts prior to installing planting soil and backfill.
 1. Strongbacks are only required during the placement and compaction of the planting soil and backfill.
 2. Move strongbacks as the Work progresses across the installation.
 3. Remove strongbacks prior to the installation of the Silva Cell decks.

- C. Install geogrid around the perimeter of the Silva Cell system where the compacted backfill and planting soil interface.
 - 1. Do not place geogrid between the edge of the Silva Cells and adjacent planting areas.
 - 2. Cut the geogrid to allow for a 6-inch (150 mm) overlap at the Silva Cell base and a 12-inch (300 mm) overlap at the Silva Cell deck.
 - 3. Provide a minimum 12-inch (300 mm) overlap between adjacent sheets of geogrid.
 - 4. Secure geogrid with cable ties below the top of the posts, along the post ridges.
- D. Place the first lift of backfill material loosely around the perimeter of the Silva Cell system, between the geogrid and the sides of the excavation. Place backfill to approximately the midpoint of the Silva Cell post. Do not compact.
- E. Place the first lift of planting soil in the Silva Cell system to approximately the midpoint of the Silva Cell post.
 - 1. Level the planting soil throughout the system.
 - 2. Walk-through the placed planting soil to remove air pockets and settle the soil.
 - a. Lightly compact soils by walking through the soil following placement.
 - b. Walk-through compaction shall result in 75% to 85% of maximum dry density at optimum moisture content in accordance with BS 1344 Part 4. Do not exceed root limiting compaction for the given soil type.
- F. Compact the first lift of backfill material, previously spread, to 95% of maximum dry density at optimum moisture content in accordance with BS 1344 Part 4 or in accordance with Project Specifications for hardscape areas, whichever is greater.
- G. Add and compact additional backfill material so that the final finished elevation is at approximately the same level of the placed planting soil within the Silva Cells.
 - 1. Maintain the geogrid between the Silva Cell system and the backfill material at all times.
- H. Place the second lift of backfill material loosely around the perimeter of the Silva Cell system, between the geogrid and the sides of the excavation so that the material is 2 to 3 inches (50 to 75 mm) below the top of the posts. Do not compact.
- I. Place the second lift of planting soil inside of the Silva Cell to the bottom of the strongbacks. Walk through compact.

SPECIFIER: For a .5xm, 1x, or 2x System, skip to Article 3.11 - INSTALLATION OF IRRIGATION AND WATER HARVESTING SYSTEM.

SPECIFIER: For a 1.5x, 2.5x, 3x, 3.5x, or 4x System, continue below.

- J. Remove strongbacks. Place the first or final post extension into the primary post. Rotate clockwise to snap in place.
- K. Immediately reinstall strongbacks on top of the post assembly.
- L. Repeat the process of adding post extensions, planting soil, and backfill, as described herein, until the requirements of the drawings and Table 2 are met. Alternately place backfill and planting soil so that elevation of the compacted backfill and the walked-through compacted planting soil are just below the level of the strongbacks at each required post extension and when the full post assembly is installed per the drawings and Table 2.

3.11 INSTALLATION OF IRRIGATION AND WATER HARVESTING SYSTEM (including but not limited to Deeproot Water+Air System components)

SPECIFIER: Water is critical to the success of the Silva Cell system; trees planted in the Silva Cell system must receive adequate water to ensure survival of the living system during periods of drier weather. Harvest of natural rainwater or supplemental water must be a part of the system, either through pressurized or non-pressurized systems, within the soil of the Silva Cell system. Coordinate with required irrigation installations. Irrigation should be installed within the entire soil system, not only at the tree openings.

- A. Install irrigation and water harvesting system in accordance with the Drawings and Specifications. Remove only the minimum number of strongbacks needed to accommodate the Work and reinstall them immediately upon completion to maintain alignment of posts.

3.12 INSTALLATION OF SILVA CELL DECK

SPECIFIER: Select either "Landscape Architect", "Architect", or "Engineer" in the paragraph below as applicable.

- A. Obtain final approval by the [Landscape Architect] [Architect] [Engineer] of planting soil installation prior to installation of the Silva Cell decks.
- B. Remove strongbacks, level out the planting soil, and immediately install decks over the post assemblies below. Place deck over the top of the post assemblies. Push decks down until the deck clips lock into the posts, snapping the deck into place.
- C. Fold the 12 inches (300 mm) of geogrid onto the top of the decks.

3.13 FINAL BACKFILL PLACEMENT AND COMPACTION

- A. Place and compact final lift of backfill material to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method, such that the backfill is flush with the top of the installed deck. Do not allow compacting equipment to come in contact with the decks.

3.14 INSTALLATION OF GEOTEXTILE AND AGGREGATE BASE COURSE OVER THE DECK

- A. Ensure geotextile meets the specifications in section 2.04 paragraph C.
- B. Place geotextile over the top of the deck and extend to the edge of the excavation. Overlap joints a minimum of 18 inches (450 mm). Leave enough slack in the geotextile for the aggregate base course to push the geotextile down in the gaps in between the decks.
- C. Install the aggregate base course (including aggregate setting bed if installing unit pavers) over the geotextile immediately after completing the installation of the fabrics. Work the aggregate from one side of the layout to the other so that the fabric and aggregate conform to the Silva Cell deck contours.
- D. Maintain equipment used to place aggregate base course completely outside the limits of the Silva Cell excavation area to prevent damage to the installed system.
- E. For large or confined areas, where aggregate cannot easily be placed from the edges of the excavated area, obtain approval for the installation procedure and types of equipment to be used in the installation from the Silva Cell manufacturer.
- F. Compact aggregate base course(s) to 95 percent of maximum dry density in accordance with ASTM D698, Standard Proctor Method. Utilize a vibration or plate compactor with a maximum weight of 800 lbs (362.87 kg).
- G. Do not drive vehicles or operate equipment over the completed aggregate base course.

3.15 INSTALLATION OF CONCRETE CURBS AT TREE OPENINGS, AGGREGATE SUBBASE AND PAVEMENT ABOVE THE SILVA CELL SYSTEM

- A. Place concrete curbs along planting areas and tree openings as shown on the Drawings to retain the aggregate base course from migrating into the planting soil.
- B. When staking concrete forms (e.g. curbs around the tree openings), prevent stakes from penetrating the Silva Cell decks.
- C. Turn down edge of concrete paving to the Silva Cell deck along the edges of tree openings or planting areas to retain the aggregate base course material.
- D. When paving type is a unit paver or other flexible material, provide a concrete curb under the paving at the edge of the Silva Cell deck to retain the aggregate base course material at the tree opening.
- E. Place paving material over Silva Cell system in accordance with the Drawings.
 - 1. The Silva Cell system does not fully meet loading strength until the final paving is installed. Do not operate construction equipment on top of the Silva Cell system until paving installation has been completed.

- F. Use care when placing paving or other backfill on top of Silva Cell system to prevent damage to the Silva Cell system or its components.

3.16 INSTALLATION OF ROOT BARRIERS

- A. Install root barrier in accordance with manufacturer's installation instructions.

3.17 INSTALLATION OF PLANTING SOIL WITHIN THE TREE PLANTING AREA

- A. Remove rubble, debris, dust and silt from the top of the planting soil within the tree opening that may have accumulated after the initial installation of the planting soil within the Silva Cells.
- B. Install additional planting soil within the tree openings, to the depths indicated on the Drawings.
 - 1. Use the same soil used within the Silva Cells for planting soil within the tree openings.
- C. Compact planting soil under the tree root ball as needed to prevent settlement of the root ball.
- D. Place trees in accordance with the Drawings.

3.18 PROTECTION

- A. Keep construction traffic away from the limits of the Silva Cells until the final pavement profile is in place. The Silva Cell system does not fully meet loading strength until the final paving is installed.
 - 1. Do not operate equipment directly on top of the Silva Cell system until paving installation has been completed.
 - 2. Provide fencing and other barriers to prevent vehicles from entering into the Silva Cell area.
- B. When the Silva Cell installation is completed and the permanent pavement is in place, limit traffic and construction related activities to only loads less than the design loads.

3.19 CLEAN UP

- A. Perform clean up during installation and upon completion of the Work. Maintain the site free of soil, sediment, trash and debris. Remove excess soil materials, debris, and equipment from the site following completion of the Work of this Section.
- B. Repair damage to adjacent materials and surfaces resulting from installation of this Work using mechanics skilled in remedial work of the construction type and trades affected.

END OF SECTION