Comparing Silva Cells and Strucural Soil

By James Urban, FASLA, ISA

Of the many approaches to improving the growing conditions for trees in urban spaces, Silva Cells, manufactured by Deep Root Partners, L.P. and Structural Soil marketed as “CU Soil” by Amereq Inc, are often specified as equal alternates. There is a belief that the two products have similar capabilities and supports similar size trees with equal amounts of product. This is simply not correct.

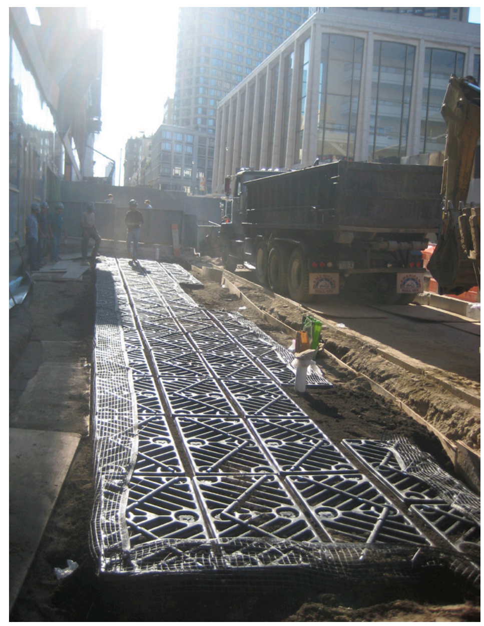
Structural Soil is made of 80% crushed rock and 20% loam soil coating the rock. The mix is compacted to 95% Proctor Density. Crushed rock has approximately 30% void space and the soil fills these voids,

Structural Soil

remaining un-compacted with the compaction force and paving loads transferred through the rock matrix. Clay loam soil is required in the mix specifications. Tree roots grow in the soil-filled voids spaces with access to air and water. Vehicular loaded paving can be built over Structural Soil.

Silva Cells are a plastic/fiberglass structure of columns and beams that support paving above uncompacted planting soil. The structure has 92% void space and is a stable surface for the installation of vehicle loaded-pavements. The Cells have a AASHTO H-20 load rating, which is the required load rating for structures such as vault covers and grates in sidewalks and parking lots. The cell structure transfers the force to a base layer below the structure. Soil within the Cells remains at low compaction rates, thereby creating ideal growing conditions for tree roots. Silva Cells are designed to allow use of a wide range of soils, with most locally available soil from heavy clay loam or silt loam to sandy bio-retention soils. Even the soil currently at the project site may be suitable if sufficient compost is added. The use of recycled or reused soil makes Silva Cells an extremely sustainable approach.

Construction of Silva Cells begins with the excavation of the area to receive the Cells. The Cells are

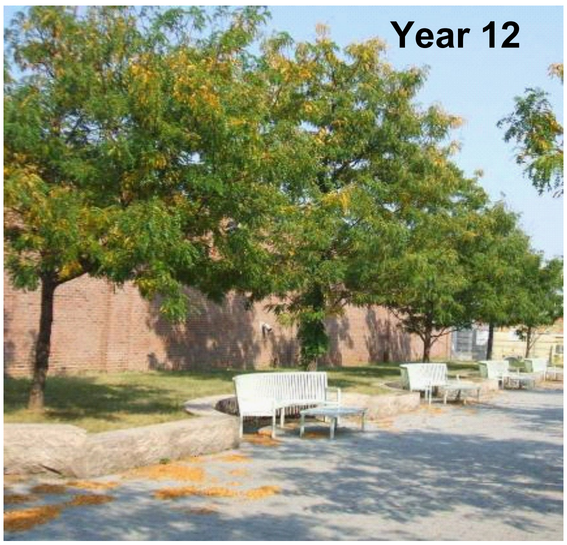


Silva Cells

set on a 4” layer of aggregate. Planting soil is placed inside the Cells and very lightly compacted to achieve optimum soil density for root growth. After the soil is installed, a deck is placed on top of columns. Geotextile is laid over the decks and aggregate is laid on top of the geotextile. 4 inches of aggregate is required under concrete sidewalks while porous modular pavers require 12 inches of aggregate. The sidewalk base aggregate is then compacted and ready for pavers or concrete. The trees are planted in traditional planting spaces between the Cells. To accommodate mature tree trunk flares, designers are still advised to make the tree planting space as large as possible. Construction specifications and details are available on the Deep Root web site (www.deeproot.com).

Soil Volume Comparisons

While tree roots grow in both Structural Soil and Silva Cells, the net amount of soil available to the tree is significantly different. The primary reason to use either of these systems is to increase available soil volume. 100 cubic feet of Structural Soil provides only about 20 cubic feet of loam soil. This is due the large amount of rock (80%) in the mix required to meet the structural requirements. By comparison, 100 cubic feet of Silva Cells provides 92 cubic feet of soil. In environments where space and budgets are always limited, ability to deliver soil more efficiently creates a significant advantage for using Silva Cells.



Trees in open loam planter:
Appr. 275 cf net soil/tree

Trees in CU Soil
Appr. 175 cf net soil/tree (350 cf of CU Soil)

Comparative Research

There are few head to head test that compare Silva Cells to Structural Soil, but enough data and anecdotal information exist to make informed conclusions. In the most complete study at the Bartlett Labs in North Carolina (Smiley 2006-2010), trees in a suspended pavement mock up of Silva Cells are out performing trees in Structural Soil after 3 growing seasons. The trees in the suspended pavement over loam soil were taller, and had broader canopies and significantly larger and greener leaves.

A 2003 study conducted at Cornell University (Bassuk 2003) concluded that trees in containers of Structural Soil were similar in growth to trees in small containers with the same net volume of loam soil that was in the Structural Soil. In that same study, trees in volumes of loam soils equal to the total volume of structural soil grew significantly larger than the Structural Soil trees.

Long-term observations of trees growing in Structural Soil compared to nearby trees in loam soil volumes of similar volumes have been recorded (Urban 2008-2010). In comparably sized spaces, some filled with Structural Soil and some filled with loam soil, trees in the loam soils have been observed to consistently grow significantly larger. At a Structural Soil prototype planting in Staten Island, New York, one row of trees were planted in Structural Soils and one row in an adjacent open loam soil planter. The open planter contained approximately 275 – 300 cubic feet (cf) of loam soil per tree. The Structural Soil trees were grown in 350 cf of Structural Soil that contained a net 70 cf of soil with an additional 55 cf of loam soil in the planting hole. The Structural Soil trees were in a total of 405 cf of material but this volume only contained a net 125 cf of loam soil per tree, less than half of the net 275 – 300 cf of loam soil available to the trees in the open planter. Twelve years later, the trees in the open loam soil planters were significantly healthier than the Structural Soils trees, many of which were in decline.

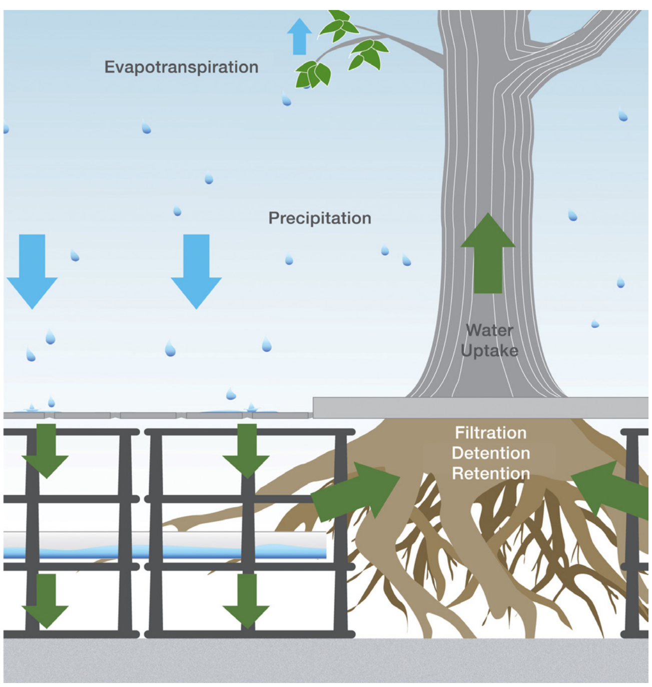
In a nine year old planting in Columbus, OH, trees in Structural Soil started out growing well, but are now showing signs of decline. At another location in the same Columbus planting, trees were grown in Structural Soil in one portion of a block while the rest of the street was planted with similar trees in similarly sized loam soil panels. Ten years later the trees in Structural Soil were starting to decline, while those in the loam soil panels were continuing to thrive. Similar observations have been made in cities as diverse as San Francisco, Chicago, and Ft. Worth.

Soil types and pH

Structural Soil must be made from a specific clay loam soil texture. This soil is normally not a problem to locate, but has created sourcing issues in some market areas including parts of New England where clay loam deposits are rare. In areas where only limestone rock is available from local quarries, the pH of Structural Soil may be greater than the proposed trees can accommodate. Either high pH tolerant trees must be used or more expensive non-limestone rock must be specified.

Rain water applications

There is a growing trend to use soil volumes for trees to treat and retain rainwater runoff in cities. Both Silva Cells and Structural Soil have been used for this purpose; however, there are significant differences in the effectiveness of each approach. Structural Soil is a very rapidly draining material (24 inches per hour). Water moves through it so fast that it does not effectively retain significant amounts of water for meaningful periods of time. This rapid drain down rate also reduces removal of pollutants.



Schematic of Silva Cell application for on-site stormwater management. Water gets in to the system through pervious pavements, drains, and more.

Image courtesy of Deep Root Partners, L.P.

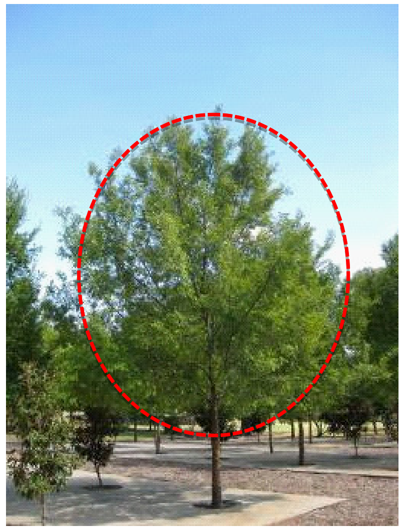
In a 2006 report on bio-retention effectiveness, North Carolina State University found that the optimum infiltration rate for various pollutant removals were: total nitrogen 1-2 inches per hour; total phosphorus 2 inches per hour; and metals, TSS, pathogens: 2 to 6 inches per hour (Hunt/Lord 2006), or a fraction of the 24 inches an hour in Structural Soil. Washington State Department of the Environment only accepts bio-retention soils with infiltration rates of between 1 and 12 inches per hour (Hinman 2009). With this information, it is not surprising that Structural Soil was found to only filter an average of 53% of the nutrient pollutants in a 2008 study (Xiao and McPherson 2008). Studies on pollutant removal in bioretention soils are significantly higher (Coffman 2002, Hsieh/Davis 2003) particularly in deeper soil depths. The soil within Silva Cells can be designed to both retain significant amounts of water and filter a wide range of water pollutants. Soil infiltration rates can be designed to be much slower than Structural Soil, thereby increasing filtering capacity, the volume of water retained, and the time of that retention.

Tree response to Loam soil

Year 6 results from an independent study by the Bartlett Tree Lab. Image courtesy of Dr. Tom Smiley.

Trees grow best in loosely compacted loam soil, the type that can be installed in Silva Cells. The ideal growing conditions mean faster tree recovery from transplanting and rapid growth. Tree growing in loam soil in Silva Cells have responded exceptionally well in numerous applications over the 6 years since their introduction. Conversely, trees growing in Structural Soil recover from transplanting more slowly and grow

Year 6: Tree growing in Suspended Pavement at the Bartlett Tree Lab.



Year 6: Tree growing in Structural Soil at the Bartlett Tree Lab.

Year 6: Suspended pavement twig on the left; Structural Soil twig on the right.

less vigorously. In addition to the type of soil and its compaction, the net volume of soil is critical to predicting the long-term growth of the tree. A typical large canopy tree needs in excess of 1,000 cf of loam soil to reach a large enough size to create significant environmental benefits. It is often quite difficult to find the space for this amount of soil along urban streets.

Sustainability

Structural Soil is made from processed hard aggregates that require significant energy to mine, crush and ship. Quarry activity is quite damaging to the local environment. Clay loam soil in many markets is often required to be shipped from outside the project area and rock quarries are also often located far from metropolitan centers. Both the stone and soil must be shipped to the mixing site, processed and then reloaded for delivery. The total energy footprint of this material is very significant. This energy footprint is compounded by the need to install 4-5 times the volume of material required for Silva Cells to achieve similar results.

While Silva Cells are made of 70% plastic material and in most markets are shipped over long distances, the Cells only represent 3% of the total mass of the required soil assembly. The efficiency of the soil system makes for far less effort to achieve similar results as Structural Soil. When locally sourced, recycled or reused soil is added to the design, significant positive impacts to the overall sustainability equations are realized. The ability to use local, natural soils may also mean that native tree species are suitable selections.

Structural Soil Conclusions

Structural Soil is limited in the amount of soil that can be provided due to the large amount of rock that it contains. Trees generally grow well until the amount of soil in the mix is exhausted, the trees must then either find a way out of the soil provided or they will begin to decline. When calculating Structural Soil to use for each tree and making predictions on the effect of the material on tree growth, only the amount of soil in the mix, approximately 20% of the total mix volume, should be considered in the calculation.

The limitations on availability of clay loam soil and use of limestone with the increase in pH has disadvantages in some regions and requires that one understand soil type availability and the geology of a particular region. Tree selections need to be adjusted for these local conditions.

Structural Soil is limited in its use as a rainwater management application. Rapid drain down limits time of retention, reducing the amount and time water is held from waterways and the amount of pollutants that can be filtered from the water.

Probably the biggest advantage of Structural Soil is that, as a loose fill material, it can fill odd shaped excavations and fit in places where Silva Cells are limited by their dimensional constraints. Structural Soil has been used in conjunction with Silva Cells to bridge spaces around utility lines and obtain incremental improvement to rooting volume around the edges and underneath Silva Cells in tight spaces.

Silva Cell Conclusions
Silva Cells offer the opportunity to install very large volumes of soil in compact urban environments to help grow mature street trees and manage rain water on site. The soil can be high quality loam topsoil or other soil types that meet the project and tree species requirements including specialty bio-retention soils and recycled or reused soil harvested from the project site or nearby locations. The system is the most efficient and cost effective approach to deliver good quality soil under pavements.

The ability to reuse locally available soil makes the system very sustainable. The modular nature of the product has proven to permit installations in tight urban spaces with numerous utilities and adjacent structures. The systems flexibility and the types of soil that can be installed makes it ideal for rainwater management where trees and soil can become a significant part of the rain water management solution.

Silva Cell systems have been installed in over 200 sites across the United State and Canada, Europe, and Australia.

Specification of these approaches as equal products
The above comparisons demand that the two approaches not be specified as equal. Value engineering recommendations to substitute equal volumes of Structural Soil for Silva Cells should not be accepted. Designers must assure that the products be designed and bid based on the amount of soil within the system, not the overall volume of material to be installed. 100 cubic feet of Silva Cells will require 400 to 500 cubic feet of Structural Soil to provide for equal tree growth. With the typical urban tree needing more than 1,000 cf of loam soil, where space is at a premium, there may not be sufficient room to install enough Structural Soil to equal the amount of soil provided in the Silva Cell design. If comparative bidding is required, two sets of drawings, one for the Silva Cell option and one for a Structural Soil option must be prepared, to reflect the difference in system size and different types of coordination required with the other elements in the urban fabric.

James Urban, FASLA, ISA is an urban soil and tree consultant in Annapolis, Maryland. He is the author of “Up By Roots: Healthy Soils and Trees in the Built Environment”. He was involved in the development of structural soils in the 1980’s and 90’s and also was on the design team for Silva Cells. As a matter of full disclosure, he receives a royalty from the sales of Silva Cells and is a technical consultant to the Deep Root Partners.

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