Tree Performance In Load Bearing Paving—Tree Growth, Health, Storm Water Results.

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“In the medical field there are so many studies that it is often difficult to make a decision, while in the urban tree field there are so few studies that it is easy to deceive.”

*Ed Gilman, a casual observation.*

“Science is not truth, it is moving away from falsehood.”

*Albert Einstein*
Tree Requirements

1. Sufficient soil volume
2. Zone of rapid root taper
3. Water in
4. Water out
5. Room for canopy growth
6. Quality nursery stock

Trunk Flare
There are many approaches to improving soils below pavement.

But they are not equal. How do we evaluate relative effectiveness vs cost?
COMPARATIVE RESEARCH AND ANALYSIS

26 research papers, and conference presentations

Controlled research plots and Monitoring / analysis of trees planted in built landscape projects.
OPTIONS CONSIDERED

**Suspended Pavement:**
*Silva Cells* (post and beam soil cells)

**Stratacells** (segmented soil cells)

**Structural Growing Media:**
*Gravel Based Structural Soils*

**Compacted Sand Structural Soil**

**Arbor Raft** (Hybrid system – depends on compacted sand below raft for soil volume)
Spanning Structures
AASHTO H-20 Loading
145kN (32,000 lb) load

Pavement subbase
Standard Proctor Test
95% of Maximum Dry Density

LOAD BEARING DEFINED

These sketches illustrate the AASHTO-approved live loading specifications for standard H20 and HS20 trucks. Source: AASHTO Standard Specifications for Highway Bridges.
RELATED FACTORS IN THE EVALUATION OF AN OPTION

**Soil limitations**
Unscreened Loam vs Screened loam
Vs Sand soils

**Existing soils**
Soil beyond the system supporting pavement

**Water harvesting**
Water into the system
RELATIED FACTORS IN THE EVALUATION OF AN OPTION

**Storm water**
Quality / quantity.

**Layout flexibility**
Conflicts with existing and proposed structures, and dimensional variations within the design.

**Volumetric effectiveness**
Effective loam soil volume.

Does each approach provide Equivalent loam soil volume in the same space?
CONCLUSIONS - Soil Volume:
1. Soil volume to tree growth is based on unscreened loam soils. Compaction, or screening, blending, sandy soils or rocky soils will require greater amount of material to compensate for the growth limitations of these soils.

2. Evaluation efforts must account for the effect of adjacent existing soils in the overall amount of soil available to the tree.
Recommendation

The “British Standard Specification for Topsoil” is NOT a reasonable tool to determine acceptable soil in load bearing applications.
CONCLUSIONS - System effectiveness:
Suspended pavement systems that are filled with unscreened loam soils are the most effective at growing trees and are equivalent to loam soil provided that the volume of the structural elements holding up the sidewalk are subtracted from the overall volume of the installation.
Sugar Beach, Toronto – Silva Cells

Trees growth in Silva Cells
408 trees / 10 projects
Urban, J. 2016
CONCLUSIONS - System effectiveness:
Gravel based structural soil with clay loam soil; the effective amount of soil in the material is between 20 and 25%. Trees can be expected to grow at reasonable rates until the roots fill the available soil space but much more material volume is needed.

More research is needed to determine if the long term soil to tree growth ratio is different for Stockholm soil.
Critique of three plantings in built landscapes plus a controlled experiment. Different results for different reasons.

Problems with mixing. Trees growing well in large open soil volumes.

In controlled test plots Trees in structural soil similar to negative control

Structural soil research and examples in Norway
Solfjeld, I. 2014

<table>
<thead>
<tr>
<th>DBH Increase</th>
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</thead>
<tbody>
<tr>
<td>Structural soil with</td>
<td>1.18cm</td>
</tr>
<tr>
<td>Storm water</td>
<td>(0.46”)/yr</td>
</tr>
<tr>
<td>Structural soil without Storm water</td>
<td>0.75cm (0.29”)/yr</td>
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<tr>
<td>Open soil bed</td>
<td>1.12cm (0.44”)/yr</td>
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</tbody>
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Stockholm solutions: Experiences of different planting methods
Ostberg, J. 2014
CONCLUSIONS - System effectiveness:

Compacted sand structural soil is difficult to evaluate for efficiency. Based on current findings, it may be reasonable to rank this option at between 30 to 50% effectiveness compared to loam soil with the further understanding that trees may never growing as fast or as large due to limitations other than volume.

The arborraft hybrid system should not be considered a load bearing approach without using compacted sand soil of gravel structural soil below the raft in sufficient volume to support tree growth expectations.
Tree growth in Sand Mix similar to “Amsterdam soil” compacted to 80% standard proctor was only about 20% of trees in sandy loam topsoil.

“Growing trees in road foundation materials.”
Kristoffersen, P. 1999
Effective Rooting Space

LOAM SOIL
1000 c.f.
28.3m³

100% EFFICIENT

Post Soil Cells
30.3m³

93% EFFICIENT

Segmented Soil Cells
1290 c.f.
36.5m³

71% EFFICIENT

Calculating EFFECTIVE rooting space!

COMPACTED SAND SOIL
2000 c.f.
56.6m³

50% EFFICIENT

GRAVEL BASED STRUCTURAL SOIL
5000 c.f.
141.6m³

20% EFFICIENT
Recommendation - Design improvements

Designers must pay more attention to all the parts of the tree in pavement problem. The choice of a soil approach is only one small part of a very complex design problem.
More Research Needed!

ASLA Tree and Soil Research Blog
https://treeandsoilresearch.asla.org

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