The Why's And How's Of Using CU-Structural Soil® To Grow Trees In Pavement.

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Why was CU-Structural Soil® developed?

Soils under pavement need to be compacted to meet load–bearing requirements so that sidewalks and other pavements won't subside and fail. Soils are often compacted to 95% peak (Proctor or modified Proctor)) density before pavements are laid. When trees are planted into these soils root growth is severely reduced or eliminated beyond the tree-planting hole. When root growth is restricted, tree growth suffers as water, nutrients and oxygen are limited.

The need for a load-bearing soil under pavement gave rise to the development of CU-Structural Soil®, a blended soil that can be compacted to 100% peak density to bear the load of a pavement while allowing tree roots to grow through it.

The concept behind it

CU-Structural Soil® is a mixture of crushed gravel and soil with a small amount of hydrogel to prevent the soil and stone from separating during the mixing and installation process. The keys to its success are the following: the gravel should consist of crushed stone approximately one inch in diameter, with no fine particles, to provide the greatest large void space. The soil needed to make structural soil should be loam to clay loam containing at least 20% clay to maximize water and nutrient holding capacity. The proportion of soil to stone is approximately 80% stone to 20% soil by dry weight, with a small amount of hydrogel aiding in the uniform blending of the two materials. This proportion insures that each stone touches another stone, creating a rigid lattice or skeleton, while the soil almost fills the large pore spaces that are created by the stone. This way, when compacted, any compactive load is being borne from stone to stone, and the soil in between the stones remains uncompacted.

How is it used?

CU- Structural Soil® requires an adequate volume of soil under pavement, approximately 2 cubic feet of soil for every square foot of envisioned crown diameter. We recommend a 36" soil depth, although several projects have been successful using as shallow as 24". We would not recommend any less than 24". CU-Structural Soil® has an available water holding capacity between 7% and 12% depending on the level of compaction. When we calculate soil volumes for CU-Structural Soil®, we use a water holding capacity of 8% to be on the conservative side.(Bassuk, et al, 2009) This is equivalent to loamy sand. Based on water holding capacity, you would need approximately 1.3 times the amount of CU-Structural Soil® as you would need for an equivalent sized tree growing in sandy loam (See the table below for soil volume recommendations). Because of its well-drained nature, trees that prefer well-drained soils do best in CU- Structural Soil®. Depending on the stone type used to make CU-Structural Soil®, the pH of the soil may be affected (e.g. limestone vs. granite). Good tree selection practices and establishment procedures should be used with CU- Structural Soil® as would be done with any tree installation.

It is important to maximize the water infiltration through the pavement to replenish CU-Soil™ as with any soil. A porous opening around the tree of at least 50 square feet is recommended to allow for water infiltration. Or, low volume, trickle irrigation may be used in regions where rainfall is not adequate.

Although CU-Structural Soil® is made of readily available local crushed stone and soils, it is essential to make it correctly. To insure quality control, CU-Structural Soil® is made by licensed producers who make it according to its specification all over the country (71 producers currently). Samples from the licensed producers are tested at an independent soils lab for compliance. Over 1300 CU-Structural Soil® projects have been installed successfully all over the US, Canada and Puerto Rico during the past 15 years. Costs range from $40-$75 per cubic yard.

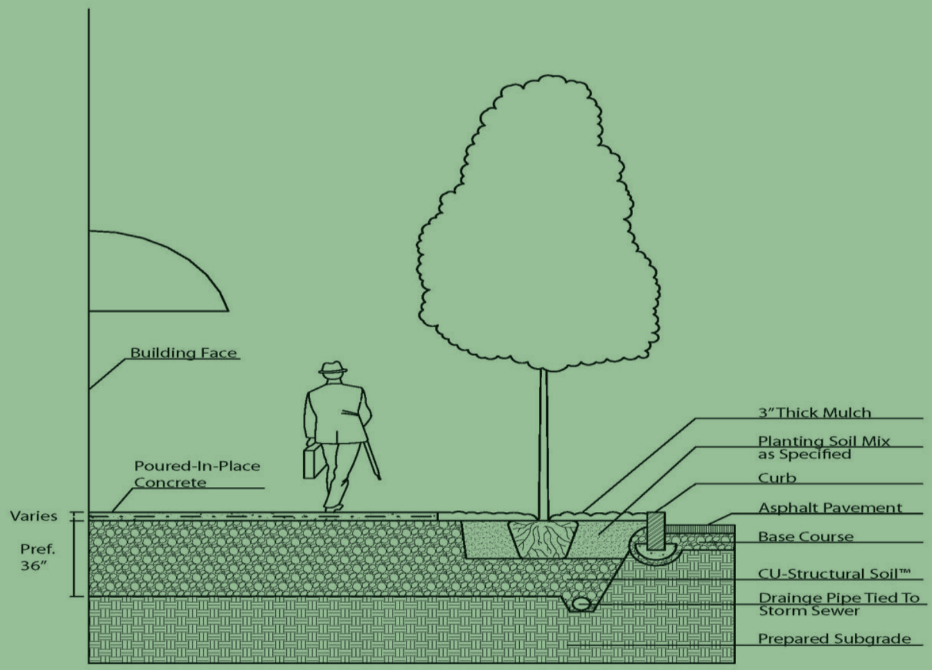

Figure 1. Cross-section of typical tree installation into CU-Structural Soil® under pavement from curb to building face. Note where the tree pit is open, topsoil should be placed around the tree ball, but CU-Structural Soil® should be placed under the ball to prevent tree ball subsidence.

CU-Structural Soil® for stormwater capture

CU-Structural Soil® has a rapid infiltration rate (>24" per hour) and has 26% porosity after it has been compacted to 100% peak density. Ordinary loam soil compacted to 100% peak density has an infiltration rate of 0.5"/hour. This allows CU-Structural Soil® to be used for stormwater capture under porous pavements. 24" of CU-Structural Soil® can hold the 100-year storm in Ithaca, NY of 6" of rain in 24 hours.

Things we've learned after 15 years of experience with CU-Structural Soil®

Tree Selections Matters

CU-Structural Soil® is very well drained and may have an altered pH depending on the stone type that is used. Limestone gravel will result in a higher pH (about 8.0) while granite and other stone types will have less effect. There are numerous trees that grow very well at a variety of soil pH. Also, as CU-Structural Soil® is well drained trees should be chosen that prefer these soils conditions. See **Recommended Urban Trees** at http://www.hort.cornell.edu/uhi for recommendations on tree that tolerate a range of pH and soil moisture conditions.

Initial maintenance matters

As with any tree, initial watering is important to get it off to a good start. This may not matter in a lawn or park situation, however, it is critical when pavement limits water from entering the soil. This happens more frequently when tree are planted in pavement. Twenty gallons of water every 5-7 days is generally adequate for newly planted trees in areas where there is adequate rainfall. In areas where trees are normally irrigated, low volume trickle irrigation works well for trees planted in CU-Structural Soil®.

Soil Volume matters

Structural soil less than 24" deep is inadequate for tree growth. Earlier trials with 12" or 15" depth of structural soil did not result in good tree growth after 12 years. Soil volume should be sized to be at least 2 cubic feet per square foot of envisioned crown projection (the area under the tree's drip line**.** CU-Soil™ depth should be at least 24", but preferably 30" or 36." The deeper the soil, the greater the soil's water holding capacity. It will also be less likely that tree roots will heave sidewalks. Research has shown the roots grow to the full depth of structural soil so radial growth of tree roots and their resulting upward force would be spread over a larger area as compared to roots that grow right under the sidewalk.

Production of CUSS according to research based specification matters

Many years of research and testing went into the development of CU-Structural Soil®. When there is at least 20% clay in the soil, the soil coats the stone and there is greater surface area for roots to gain the water and nutrients they need**.** This clay content is critical to achieve adequate nutrient and water storage. There is also 3-5% organic matter in the soil helping it to achieve a good cation exchange capacity and to feed soil microorganisms.

Soil volumes of CU-Structural Soil®, Sandy Loam and Loam necessary to support a large tree in the Midwest or Mid Atlantic US without irrigation after 3 years of establishment.

Tree size	Crown projection, (square feet)	Available water holding: 8% (CU-Soil)	Available water Holding: 12% (Sandy loam)	Available water holding: 15% (Loam)
Large Tree, Crown diameter 30'	706.5	37 cu yds.	30 cu. yards	25 cu. yards

(37 cubic.yards of CU-Structural Soil® assumes loam soil will be placed around the tree ball, but Not under the ball in the pavement opening of approximately 7' x 7' or 5' x 10')

For more information on the research and use of CU-Structural Soil® go to:

Cornell Urban Horticulture Institute Structural Soil website:
http://www.hort.cornell.edu/uhi/outreach/csc/

Grabosky, J, Haffner, E and Bassuk,N.L. 2009. Plant Available Moisture in Stone-soil Media for use Under Pavement While Allowing Urban Tree Root Growth. *Arboriculture & Urban Forestry* 35(5): 271-278