REDESIGNING PAVING PROFILES FOR A MORE VIABLE URBAN FOREST

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As we approach the millennium, the practice of landscape architecture is challenged to create more sustainable cities and to wisely and efficiently use resources at our disposal. One aspect of practice that has rarely been understood is the design, specification and installation of trees in increasingly complex urban environments. The Americans with Disabilities Act, A.D.A., along with performance-based pavement profiles have created design challenges to sustain tree-plantings in media which provide required structural-loading of pavements while supporting the health and vigor of trees in our streets, plazas and parks. One of the great design failures of the late Twentieth Century is the unsuccessful installation of trees and the establishment of the urban forest.

The fact that trees have a difficult time surviving amid the conditions of our urban centers is not a surprise. Urban areas for the most part are not designed with the specific requirements of trees in mind. Trees are often added as afterthoughts into an environment built for cars, pedestrians, buildings, roadways, sidewalks and utilities. It is not surprising that studies point out that trees in urban centers surrounded by pavement live for an average of seven years while those in tree lawns, the narrow strips of green running between the curb and sidewalk, live for up to thirty-two years (Moll, 1989; Craul, 1992; American Forests, 1997). These same species might be expected to live anywhere from 60 - 200 years in their native habitat or in a park-like setting.

Although there are a virtual litany of environmental insults that urban trees may experience, the most significant problem that urban trees face is the scarce quantity of useable soil for root growth (Lindsey, Bassuk, 1992). When this is provided, trees fulfill the functions for which they were planted, including shade, beauty, noise and wind abatement, pollution reduction, wildlife habitat and the creation of civic identity. An adequate soil volume is key, since soils are where nutrients, water and air are held in balance that allows for root growth and water and nutrient uptake. Many urban conditions, such as air and light pollution, are commonly thought as having an impact on tree growth, but these have been found as having little significance relative to adequate soil volume for tree growth and vigor.

Under the sidewalk there is a potential for a large volume of soil that would be adequate to allow trees to reach their design potential. Our proposal is to use a "structural soil" *(Figure 1)* that would meet the specifications for a dense, load-bearing medium on which to lay pavement while simultaneously allowing for unimpeded root growth under the pavement. This is accomplished by creating a gap-graded, soil system that could be compacted to 100% Proctor density while still allowing roots to grow through it. The primary component of this "soil" system is a uniformly sized, highly angular crushed stone or crushed gravel, ranging from 3/4 to 1 -inches in size with no fine materials. If this nearly single-size stone is compacted, the stones would form an open stone skeleton with about a 40 percent porosity. Friction between the stones at contact points would "lock together" forming the load-bearing skeleton of the mixture. The second component of this mixture is a soil which partially fills the void spaces between the stones. As long as we do not add too much soil, the soil in the voids will remain largely non-compacted and root penetrable.

In addition to a structural soil for pavement support and loading which provides for trees root growth, additional research has allowed for the installation of a permeable pavement that "breathes" in conjunction with structural soils that support tree growth beneath these pavements. This permeable pavement not only allows for soil aeration critical for root growth but also water infiltration through the paving profile.

A Cornell study (Evans et al.,1990) showed a linear relationship between the percentage of granular material found between the pavers and the infiltration rate per unit area of sidewalk. Since the joints between the pavers are the point of infiltration, the type of material used to fill these joints is critical. It was found that the thickness of the pavers and thus the depth of the joining material had a minimal impact on the infiltration rate, but that a loss of material from the joints resulting in a micro-reservoir would significantly increase the rate. Not only would these micro-reservoirs retain water and effectively lengthen each rainfall event, but would also result in an increase in the head of water, causing an increase in infiltration rate. *(Figure 1)*

From these findings, the following recommendations can be made:

1) Maximize open areas of the joints of unit pavers. Choose small surface area unit pavers, using thicker pavers if necessary to compensate for loss of stability. The choice of pavers with crenellated or curved edges will increase open-soil areas. Specify wide spacing of the pavers (1/4-inch-wide joints are probably the maximum without reducing stability).

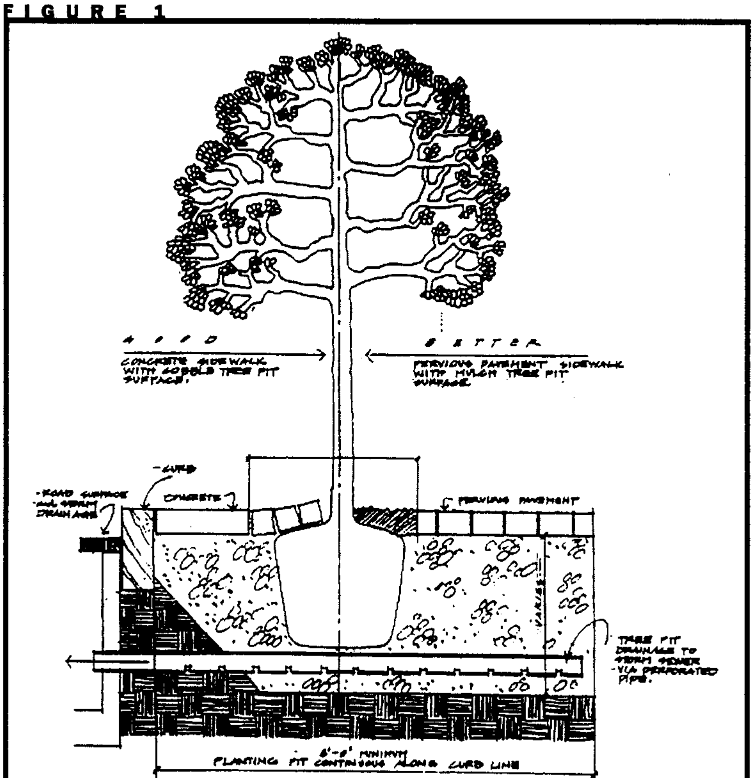
2) Use permeable jointing materials. Of the materials tested, a course grade, bitumen-bound sand is found to be the most permeable as compared to sand-cement mixtures or even straight sand. After initial installation, settling-in of the pavement occurs, and it is advisable to brush more jointing material into the joints in lieu of accumulating debris that blocks the jointing space.

3) Textural discontinuity should be avoided between the bedding layer and the underlying soil or base course. The bedding and jointing layers should be as coarse as possible to prevent a saturated water zone from forming and to reduce the quantity of water retained by these surface layers.

4) Install pavements with primary joints running across slopes to reduce runoff, and increase the detention of rainfall in the joints.

Specifications, design details and equally important successful case studies, including projects in Ithaca, New York and New York City, that demonstrate the innovative use of permeable pavements and structural soils, are important for both practitioner and educator consideration in site use. Post-installation assessments have shown that not only has there been excellent root growth, but roots grew deeper in the pavement profile reducing the threat of pavement heaving. The combination of structural soil and pervious pavements has the ability to sustain healthy tree growth. Appropriate species and maintenance practices associated with these technologies are critical considerations, including trees which tolerate higher pH and well drained conditions. More complete post-installation assessments of case studies and advancements in specifications and details will develop as this porous pavement and structural soil profile is evaluated in a variety of environmental settings around the world.

FIGURE 1



Structural Soil as a Base Under Pervious Pavement