SIDEWALK DESIGN

Strategies for healthy root systems in urban plantings ❑ Of all the indignities heaped on urban street trees, the treatment of the unseen root zone is the most ignored, until an uneven sidewalk surface jars it back into our consciousness. The usual consideration given to the root zone is a traditional horticultural approach: individual tree pits are ameliorated with organic matter and the trees are planted and staked, watered and then paved around. Since street-tree mortality is high, this planting practice needs to be more closely examined. A 1978 study in Boston indicates that water stress is the most common reason for untimely street tree deaths. Many other studies have attributed damage to poor soil drainage, soil compaction, high salt levels and alkaline conditions.

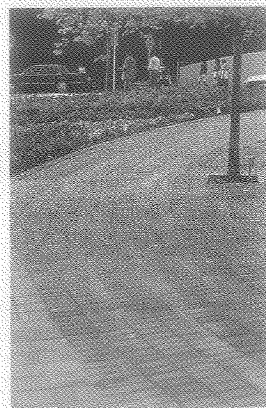
ARNOLD ASSOCIATES

The aerial environment in urban areas is greatly different from that in the forest, and so too is the subterranean environment. Urban soil is distinct from natural soils in that it is modified by man, rather than through the processes of weathering and time. Urbanization contributes unique amendments and contaminants, including solid, liquid and gaseous wastes. Urban soil characteristics include: great vertical and spatial variability; a modified structure leading to compaction; modified pH (usually high); interrupted nutrient cycling and modified soil organism activity; and the presence of anthropic materials and other contaminants, including modified soil temperature regimes. The act of planting compounds many of these problems, particularly the abrupt changes in soil profile.

This change in soil profile occurs at three distinct interfaces: between the root ball and the tree-pit soil (if the tree is not planted bare root); between the tree-pit soil and the ambient urban soil; and between the tree-pit soil and the sidewalk. In a 1989 study at the Cornell Urban Horticulture Institute, tests were carried out to better understand the impact of the sidewalk on water and air movement related to the root zone of street trees. Recommendations based on this study were combined with other research findings to work toward successful street-tree planting strategies.

In the Northeast, winter temperatures can cause soil to freeze several feet deep. Pavement details for the Northeast usually specify an eight-inch base course covered with poured-in-place concrete slabs, scored at approximately five-foot intervals to anticipate cracking at freezing temperatures. Every 10 to 12 feet, expansion joints are incorporated between slabs, with spaces three to four feet square cut out of the slabs to provide planting holes for trees. After planting, the surface of this hole is covered with a tree grate or, more commonly, left as bare soil.

In older American cities such as Boston, brick paving can be found around street trees, and in New York City, asphalt "hex" pavers and granite setts are often used. Studies have indicated that unit pavers are semi-permeable to rainwater and thus should provide a better environment for tree roots than concrete walks. In other cities, however, there is some resistance to the extensive use of unit paving because of doubts about its durability and rigidity.



Concrete unit pavers in Atlanta's Peachtree Plaza are laid on a bed of finely crushed stone that permits easy percolation to root systems.

BY

MATTHEW EVANS,

NINA BASSUK AND

PETER TROWBRIDGE

Concrete-block paving, a recent introduction from Europe, is rapidly gaining acceptance. The Cornell study used concrete pavers as a model for investigating the effects of unit paving on the subterranean environment around tree roots. Laboratory tests were followed by field tests on a newly-installed sidewalk to observe the effects of time and traffic on its permeability to water. (Although the pavers can be used for surfacing streets, the study was confined to the sidewalk.) The aim was to produce recommendations that would maximize rainwater infiltration down to the root zone, without adversely modifying the structural integrity of the sidewalk.

The Cornell study corroborated earlier studies showing a linear relationship between the percentage of open soil found between the pavers and the infiltration rate per unit area of sidewalk. Since the joints between the blocks are the point of infiltration, the type of material used to fill these joints is critical. It was found that the thickness of the blocks 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 reservoir would significantly increase the rate. Not only would these microreservoirs retain water and effectively lengthen each rainfall, but would also result in an increase in the head of water causing an increase in infiltration rate.

Although the composition of the joining material was modified over time through the action of rainwater, traffic and the accumulation of debris, the joints still remained permeable many years after installation. Permeability seemed to decline over time, however, as the material became more compacted and as debris filled up the joints. A 1987 study correlated runoff coefficients of between .348 and .640 for 10-month-old concrete-block pavements for rainfall rates from 0 to 30 millimeters per hour.

Typical specifications for concrete-block paving call for the base course to be laid on the compacted ambient soil. A sand bedding layer is placed over the base course and the blocks are hand- or machine-placed on this. The joints are

FOR TREE SURVIVAL

filled with sand and the whole sidewalk compacted with a vibrating plate compactor. It has been found that the difference in texture between the bedding layer and the underlying base course interrupts the downward flow the water. In other words, the surface bedding layer must first become totally saturated before water may move into the base course below. This also means that water from small rainfalls may not penetrate to the root zone, and will be lost from the ground through subsequent surface evaporation.

This finding of retained water in the surface layer is supported by numerous observations of root growth proliferating in the joints and directly beneath unit pavers. Since root growth occurs only where there is adequate water and oxygen, this superficial root growth has been attributed to compacted soil leading to inadequate oxygen levels except at the pavement surface. But even where a very porous, well-aerated soil is used beneath the pavement, the same phenomenon occurs, with water availability at the surface as the main cause.

From these findings, the following recommendations can be made:

1. Maximize open soil in the joints of unit pavers. Choose small 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 coarse grade, bitumen-bound sand is found to be the most permeable. 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 finer debris that blocks the pore 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. If climatic conditions make the inclusion of a base course below the pavement necessary, then a "fruit-cake" mix of coarse slag (8-15 centimeters diameter) and a free-draining, non-compacting sandy soil (about 2:1v/v) should be used instead of gravel. The slag will provide stability and porosity even when compacted.

5. Install pavements with primary joints running across slopes to reduce runoff, and increase the detention area of the joints.

6. Use continuous tree pits to run the length of the pavement. These bands of good soil between tree pits will effectively increase the size of the root zone for each tree, and will result in a designated root zone which can be seen as distinct from zones required for underground services. An ongoing study noted that street trees form one-sided root systems, with an abrupt cessation of root development at the interface of the street and the curb. The use of continuous tree pits will encourage balanced root growth along two opposite sides of the tree.

7. Incorporate tile drains into the bottom of the continuous tree pits to prevent waterlogging above the underlying ambient soil.

NATIONAL CONCRETE MASONRY ASSOCIATION

A German *woonerf* features concrete rounds laid on gravel to facilitate percolation.

In many instances, existing root zones will require amelioration, and, since the sidewalk profile cannot be uniformally modified without destroying much of the root system, point treatment is necessary. If the sidewalk is being replaced with new unit pavers, the use of a geotextile mat below the pavers will help reduce compaction by spreading the load. Poor aeration caused by soil compaction can be improved by using perforated, capped aeration pipes. Vertical mulching by drilling auger holes filled with humus will create islands for optimum root growth. Poor drainage can be rectified using subsurface drains.

The careful design of the pavement profile can result in better water infiltration and air movement, minimum compaction of the soil and good drainage. More careful attention to planting details and a few relatively inexpensive modifications to traditional street tree planting procedures should result in healthier trees and long-term savings. ■

Matthew Evans is a landscape architect practicing in London, England. Nina Bassuk is assistant professor and director of the Urban Horticulture Institute, Cornell University. Peter Trowbridge, ASLA, is a professor of landscape architecture at Cornell.