ENLARGING RESTRICTED ROOTING SPACE FOR URBAN TREES
By Jitze Kopinga

Background and key problems

Urban trees often have limited rooting space that often is restricted to only the dimensions of the original planting hole. As a result of this, the supply of water and nutrients to the tree in shorter or longer term is insufficient to have the tree grown out in a healthy state to its normal size. For this reason, the green structures that city planners intend to create are realized only on a very long term and if so, often at the expense of considerable efforts.

In the past, i.e. from the seventies on, the have been several publication in the vocational literature on the minimal rooting space urban trees require. Most of the calculations in these papers were based on the needs for water and a few were also based on the nutrient supply, especially nitrogen.

As a rule of thumb, it is assumed nowadays that an "average" tree needs approximately ¾ m3 rootable soil for each m2 of its crown projection. This applies for circumstances in which the tree is totally depending on the annual precipitation of water that falls during the growing season together with the quantity of water that has been stored into the soil during the winter period. In circumstances where the trees water demand also can be (partly) covered by ground water a rootable soil volume of ½ m3 per m2 crown projection is considered to be sufficient. With regard to the nitrogen balance this also is an adequate volume. This means that generally trees of the third height class (small trees) will do well, at least for the first two or three decennia, with about 9 m3, trees of the second hight class with 16 m3 and trees of the first height calss with 25 m3 of rootable soil.

Subject to specific properties of the tree species, such as total leaf surface (usually expressed as Leaf Area Index), leaf nitrogen content, leaf evaporation c.q. drought sensitivity, the afore mentioned dimensions may be adjusted downwards to some extent, depending on various environmental conditions as nitrogen deposition from the air or from the excrements of pets together with growing site construction that facilitates the tree to get precipitation from a larger area than merely the surface of the crown projection.

Suggested (and meanwhile no more suggested) actions to be taken

A traditional approach to enlarge and also improve the volume of rootable soil, is to drill a large number of holes into the soil underneath the crown projection which are backfilled with a soil mix or substrate with usually a high content of organic matter. If there is a risk for damage to underground obstacles the holes can be made by means of air (under pressure or vacuum) or water.
A draw back of this approach is that the total volume of soil that is ameliorated this way is relatively small and usually only a fraction of the standards presented above.
Moreover, the new root development mainly will be restricted to only these points of loosened soil. All in al this will make the tree more liable to drought when the water in these small pits is rapidly extracted by the root that has developed in there. Of coarse this disadvantage is of less influence when by making the holes compacted soil layers that prevent root penetration

are disturbed and as a result roots are able to explore more of the total soil volume of the root projection or escape to better surroundings.

A variant of how to get tree roots out of a planting hole in an otherwise compacted soil out to near by verges or gardens is the installation of so called root tunnels already during the construction of the growing site. Various materials and methods can be applied for this purpose such as spacious (diamater ca. 30 cm) PVC pipes or the vertically placed so called aeration sheets. The advantage of these methods is that the “conflict” between bearing capacity of the soil (for the sake of traffic) and its rooting possibilities (for the sake of the tree) is avoided to some extent.

The above mentioned example applies to the many existing situations in which there are restricted possibilities to created enough rootable soil volume directly around the planting hole. However, with regard to avoid damage to vital tree roots, for instance during excavation activities, it is more advantageous to have most of the roots at not too far away from the tree. For that matter a variety of methods are eligible.

When it is possible, for instance by shifting some utilities a couple of meters, the positive effect of a trench of 1 x 1 (w x d) meter along one or more sides of the planting hole already will be considerable. This soil from this trench must be exchanged, or mixed with high quality substrate with sufficient organic matter. When using large quantities of such enriched mixtures it may be necessary to also install a couple of soil aeration pipes as these mixtures tend to have an increased rate of oxygen conversion during the first period of at least several months after it has been processed.

Sometimes a shallow ground water table may be limiting for the depth to which a planting hole can be enlarged. But also there may be other circumstances that restrict diffusion of oxygen to a required depth. For so far the latter can not be improved by a lasting aeration system raising the level of the total planting hole may be a solution. This also may have the advantage of protecting trees this way against damage by traffic or the influence of deicing salt (in situations when a salt/snow mixture should be shifted away from the road onto the planting site) and if desired it can be combined with architectural accommodations such as seats or benches.

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<u>Directives with regard to the planting hole mixture</u>

An important question is to what extent the top layer of the planting hole will be used for activities that give rise to soil compaction and to what extent eventual paving over the planting hole will be affecting the diffusion of oxygen and rainwater into the subsoil (te latter is especially important when ground water cannot be utilized.
When none of these activities will happen a usual high-grade soil mixture can be applied without objection, for instance a sandy soil containing a small quantity of clay (up to ca. 10%) and with an organic matter content of up to 8 % (w/w) or even more.
On the other hand, in situations where the load baring capacity of the soil is also important, for instance when cars will be parked above the root zone, soil mixtures that warrant sufficient bearing of these loads have to be applied.
Already from some decennia ago research has been carried out into the development of so called structural soils. These can be sand mixtures of a texture that after some slight artificial compaction gives enough structure for load bearing and also still allows to penetrate and develop (the so called Tree sand). It also can be a high-grad substrate to which coarse material

(such as rubble, lava stone or expanded slate) is added to such a content that after filling of the planting hole, the element of the coarse material will provide some kind of skeleton structure that is very hard to compact.
A drawback of such a skeleton soil is that the coarse elements contribute relatively little to the nutrient and water storing and delivering capacity of the soil mixture in its entirety. An advantage, on the other hand, is that the soil mixture in between the hollows of the coars elements may be richer in organic matter than the maximum that applies for tree sand. For that matter, a kind of underground skeleton also can be created by the using load distributing plastic constructions such as beer crate shaped boxes (city of Apeldoorn) or concrete constructions or pilers. The latter however are relatively expensive.

An aditional advantage of both the structural soils as the self bearing constructions is that intentional and unintentional excavation within the rooting zone of the trees is discouraged and people are invited this way to look for more tree friendly solutions. Besides that, when the rootable soil volume within this construction is of sufficient dimension, eventual rot damage outside it will hardly affect the further growth and development of the tree.

There may be situations where merely the application of load dividing slabs will be sufficient to prevent soil compaction and its use can be considered when entrance of water and oxygen into the rooted zone is not too much adversely affected. For this purpose, the slabs must be rigid enough to divide the pressure of the loads. The foil material that is frequently used in civil engineering is too weak for this purpose and therefore not suitable unless it is combined with a sturdy construction. This accounts also for plates that are build of two layers of non woven foils kept apart by a mat of coarse plastic wire (for instance “Enkadrain 112”). The additional value of this material is that it may facilitate the entrance of oxygen in the subsoil. Also it might be expected that it will reduce condensation of moisture just underneath the pavement too some extent. This could be of importance with regard to eventual development of root damage to pavement during the coarse of time but the merits of the material with regard to this specific purpose are not sufficiently known yet.

PREVENTING DAMAGE TO PAVEMENTS BY TREE ROOTS

By Jitze Kopinga

Background and key problems

Damage to road pavements by tree roots is a well known phenomenon where trees are standing alongside roads. Because of road safety aspects the road manager is obliged to control this damage and repair the pavements which may give rise to considerable annual expenses.

Tree roots develop underneath pavements because they are attracted by the relatively high moisture content of the soil directly underneath the pavement as a result of condensation of water vapour. Because the quantity of water however is low and likewise the amount of nutrients in the road sand, roots branching is not abundant and usually roots bridge the width of the road within one growing season. Once the opposite verge is reached, rooting will be more intensive and this enables the few roots underneath the pavement that are connected to the tree to increase in thickness. As these roots mainly are located in te boundary layer between the sand and the pavement, it only takes a while (from only a few years on) when they start to lift up the pavement, tipping off tiles from stone pavements or causing more or less transverse cracks in asphalt pavements that gradually grow deeper and wider.

Suggested (and no longer suggested) actions to be taken

There are roughly three strategies to solve the problem of root damage: Tree based strategies, Infrastructure based strategies and root zone based strategies. Within tree based strategies, the first is to see what can be achieved with the choice of tree species. It is know that root damage especially occurs where so called pioneer species are planted such as Willow (*Salix spp*.), Poplar (*Populus spp*.) Blach locust (*Robinia pseudoacacia*) and Birch (*Betula spp*.). On the contrary Pendunculate oak (*Quercus robur*), Beach (*Fagus sylvatica*) and Lime tree (*Tillia spp*.) will give substantially less damage in comparable circumstances and conditions.

Apart form this pioneer “behaviour” of the species there appears to be a trend that the shallow rooting species more often cause damage than the species that naturally develop a deeper root system. It will be evident that smaller trees as a rule will cause less damage than bigger trees, however there are a few exceptions such as Sea buckthorn (*Hippophae rhamnoides*). Otherwise also the so called non aggressive trees will cause damage when the rootable soil volume is so small that tree roots simply are forced to escape from the planting hole underneath the pavement to look for better surroundings. This means that choosing the right species will only meet the problems of root damage to some extent if the tree’s growing conditions are sufficiently met.

Formerly it was assumed that damage could be prevented when tree roots were kept away from the pavement by enticing them to location within the root zone where the soil was of good quality (e.g. by soil amelioration). However, it appears that tree roots, obviously because of their opportunistic behaviour, also develop root underneath pavements under circumstances where the quality and volume of the growing site are quite generous and the tree’s demands are abundantly met. Although there are not sufficient research data to support the theory, there