APPENDIX 2

PREVENTING DAMAGE TO PAVEMENTS BY TREE ROOTS

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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 is some evidence that the occurence of damage will be less, or in a later stage, when trees are properly planted in a large enough planting hole. On its turn this also has the advantage that when for some reason too far out growing root has to be removed, the damage to the tree roots will be comparatively low and will have only negligible effect on the further growth and development of the tree.

Probably the most effective civil engineering solution is an underpinned pavement, free from the soil and also the tree roots (the so called floating construction). No doubt this is a rather expensive solution, but it may be considered in situations where root development underneath the pavement is necessary for reasons of sufficient rooting space.

Another, considerably cheaper solution refers to the choice of the material for the road bedding. Root damage mainly, if not solely, emerges at light constructed pavements that are laid down directly on top of a bedding of compacted sand. Research has pointed out that when coarse gravel is used instead of sand, there will not be, or hardly not be, any root development directly underneath the pavement even not after a period of several (say 10) years. Probably this can be explained from a combination of mechanical restraints created by the gravel elements and so called air pruning because of the large hollows in between the coarse elements. It has been shown that the effectiveness will decrease substantially when these hollows are filled with sand.

A method that has found only little utilization in the past is the use of a root cutter by which roots that have developed or were going to develop, underneath the pavement were cut off just alongside the pavement to a depth of about half a meter or even more. Especially the frequency in which he method has to applied to give effective and lasting results (and therefore the involved costs) and also the risk to damage underground obstacles such as utilities appeared to be limiting its application in practice. It also appeared that when thicker roots already had developed underneath the pavement and were cut off, new roots or even shoots would develop from the cut off parts and on their turn would damage the pavement after some time. However this may be inhibited or reduced by using herbicides on the cut off edges, but apart from the effectiveness of these agents, and the difficulty to apply them under these specific circumstances, the use of herbicides in urban green nowadays is not allowed anymore in many European countries because of changed legislation.

This implies that when repairing root damage, either the roots have to be dug out and removed, or the pavement has to be repaired in such a way that the existing roots are bridged over and kept free from the new pavement. The latter of course is far less harmful for the tree. When sidewalks or bicycle roads are concerned, also application of flexible paving material may be considered. In this case, over some length (usually those of the root projection of the tree), a pavement of asphalt or tiles is replaced by a rubber mat on top of a layer of sand and/or recycled plastic. On one hand this will spare the tree roots and on the other eventually arising unevenness generally will be of acceptable proportion with respect to the passableness and safety of the pathway.

A increasing widely used method is the application of mechanical barriers such as plastic foils or screens, the so called anti root screens. As a rule these screens are placed vertically in the soil to a certain depth. Various materials and systems have been developed and tested for this purpose. Water impermeable plastic foils appear to fence off root penetration effectively provided that they are mechanically strong enough i.c. will not be damaged when they are installed. Water permeable foils of the types that are frequently used in civil engineering (so

called geotextiles) and made of non woven plastic fiber may have positive effect but this will depend also on their thickness. Root penetration may occurs through the thinner materials although the number of roots that grows trough the foil in first instance will be lower than the number of roots that will bend away from the screen in alongside directions.
Trough the thicker materials in first instance some fine root may penetrate, but it is questionable if they will develop too thick roots as they are pinched of at the point of entrance after a while. The more rigid, thicker plastic screens are applied either circular (around the root system of a tree) or linear (alongside the pavement of the road). A drawback of the circular screens is that initially the tree will grow in a so called flowerpot situation with its subsequent negative effects (drought sensitiveness and nutrient deficiency).

Depending on the possibilities for root development, there also may be a risk for instability of the tree on longer term. The biggest drawback however is that some roots of the tree still will tend to grow up to the surface again on the other side once they have passed underneath the screen. It does need no further explanation that, although the screens may have a marked effect, this “imperfection” also will decrease its application on a large scale.

Apart from that, irrespective of the type of material tree roots growing underneath the screens always can be expected when vertical mechanical barriers are not placed deep enough into the soil i.c. reaching into the permanent anaerobic zone of the soil (or down the lowest level of the ground water table).

Root also may grow along the top of the screen when it has insufficient connection with the pavement or when the screen in its entirety has been installed too deep or when the top of the screen has been weathered by sunlight or frost or damaged by e.g. grass mowing equipment. Anyway, these aspects have to be considered when choosing the materials and applying the methods.

Table 1. Indicative list of some common street trees of first size (h > 12 m) and the frequency in which damage to pavements is observed in The Netherlands. (Indications between brackets are based on a statistically low level of observations and must be regarded as provisional)

Species	**Frequently**	**Occasionally**	**Rarely**
Acer platanoides			x
Acer pseudoplatanus		x	
Acer saccharinum	x		
Aesculus hippocastanum			x
Ailanthus altissima		(x)	
Betula spp.	x		
Carpinus betulus			x
Catalpa spp.		(x)	
Celtis spp.		(x)	
Corylus colurna			x
Fagus sylvatica			x
Fraxinus excelsior		x	
Gledisia triacanthos		x	
Juglans nigra			x
Pauwlonia tomentosa		(x)	
Pinus sylvestris	x		
Platanus acerifolia		x	
Populus alba	x		
Populus nigra	x		
Populus simonii		(x)	
Populus spp.	x		
Quercus robur			x
Quercus rubra		x	
Quercus palustris		x	
Robinia pseudoacacia	x		
Salix alba	x		
Sophora japonica		(x)	
Sorbus spp.			x
Tilia spp.			x
Ulmus spp.		x *	
*: also depending on type of rootstock			