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Tree Root Damage to Pipes

Root and pipes

It is important to understand that tree roots are biologically optimised organs that are responsible for the uptake of water along with dissolved elements and compounds. They have no perceptive or cognitive organs and so have no way of knowing where water is located until they are stimulated by physical contact with an appropriate amount of readily available water, sufficient enough to stimulate root growth.

Contrary to popular belief, tree roots do not go in search of water. Furthermore, because roots require available moisture to stimulate growth, at no stage do roots go searching for water when the soil is not appropriately moist. Rather the opposite is the case. Tree roots are opportunistic and they are stimulated, elongate and divide more rapidly as moisture levels and the surrounding temperature approaches optimal levels for the particular species. (It is this principle that drives the hydroponic industry)

An understanding of the mechanisms that drive root growth, namely soil moisture and temperature within the required range for the plant, and to a lesser extent available minerals, is vital in understanding that roots seldom break pipes and then enter them. In almost all circumstances roots enter through joins or cracks and breaks in the pipe work (see Forces applied by tree roots below).

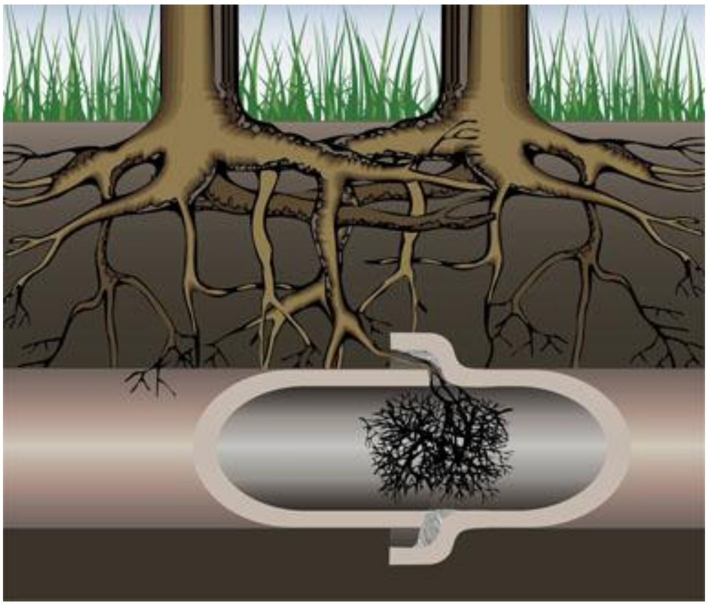

Diagram 1: Once roots enter faults in pipes, they divide rapidly.

Cracks in pipes often occur over time and the failure of cement joins and rubber seals are quite common. Once a pipe cracks or a joint fails, then pipes start to leak oxygenated and nutrient rich water through those faults into the surrounding soil. If a root comes into contact with this ideal growing environment it then starts to divide rapidly in order to take advantage of the available resources. In this situation it is generally only a question of time before roots come into contact with the fault and enter into the pipe where they divide even more rapidly

Forces applied by roots

In the past, it has sometimes been suggested that tree roots break or dislodge pipes and, whist this may occur in rare circumstances, the likelihood of it occurring are quite small. Macleod and Cram[1] (1996) state that tree roots exert a pressure in the order of 800 - 900kPa[2], dependant on species. They also provide calculations that demonstrate that roots can readily lift light structures such as driveways and pathways.

On first appearance then, it may appear reasonable to conclude that tree roots can easily crush and certainly dislodge pipes. This, however, is simply not the case and the explanation can be readily provided with some basic physics and supported with regular observations such as those contained in the video footage provided.

A pipe is comparatively easy to crack when it is not supported by soil. In order to crush a pipe, where the sides of the pipe are supported by soil, a root needs to exert enough force to push the curved wall inwards. For the pipe to crack and fail a defect in the pipe needs to be present, or the outer portion of the pipe wall must be compressed. (See diagram) The load bearing capacity of baked clay is very high and this combined with the curvature of the pipe and the support of the surrounding soil means that the inward failure of a pipe due to forces from root growth is a rare occurrence. The impact of curvature on wall strength is well demonstrated by the childhood experiment of trying to crush an egg when pushing from either end.

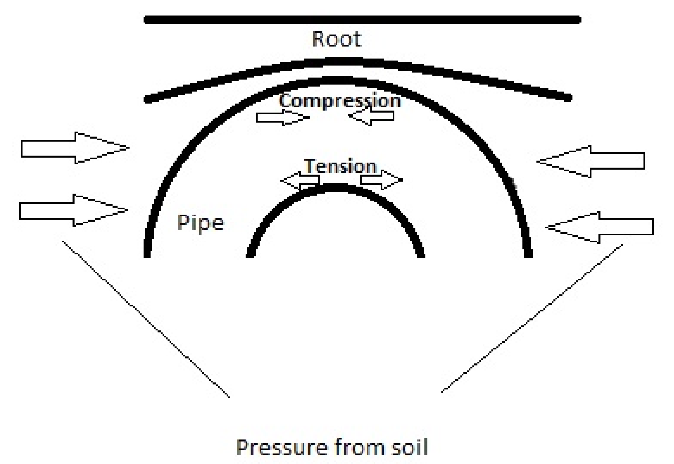

Diagram 2: When soil provide supporting pressure to stop flattening, a pipe becomes more resistant to breakage
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Roberts Jackson and Smith[3] (2006, p 395) state that *'Cases where pipes have been broken as a result of root growth are reported to be rare.'* And again (page 398) *'Most authors concur that roots do not break pipes or force their way into pipes'* but they cite several authors who disagree perhaps based on anecdotal evidence of events such as those discussed in the next subheading.

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[1] **MacLeod R D. and Cram W J.,** 1996. *Forces Exerted by Tree Roots*, Arboriculture Research Information Note, 134/96/EXT

[2] The turgid pressure applied by most cells, either plant or animal, is within the same order of magnitude. If the force in the opposite direction is too great the cell will rupture or be unable to divide. As a result there are upper end limits on the mass that can be lifted by roots.

[3] **Roberts J., Jackson N. and Smith M.**, 2006, *Tree Roots in the Built Environment*, The Stationary Office, Norwich

In trying to deal with this issue from a theoretical engineering perspective details on the pressure exerted by roots and posed the scenario were provided to an engineer who responded as follows … *'I checked on some web sites and the crushing strength of a 100mm glazed vitrified clay pipe is 34 kN/m. So if a root is exerting a pressure of 800-900 kPa, and it runs parallel to the pipe (worst case), then this is 0.8-0.9 kN/m, and so much less than the pipe crushing strength. This is very simplistic, but shows there is not too much to worry about, at least for new pipes.'* Professor Mark Stewart, (pers. Com 2011).

It appears highly unlikely that roots can ever crush or crack pipes simply as a result of their growth in girth unless the pipes is defective or significantly embrittled.

When it comes to a root moving a pipe laterally, this may at first instance seem more likely. However, this is also not the case. In order to dislodge a pipe the root must push the pipe into the surrounding soil. In soils that do not readily compact, such as sand, the support of the pipe is so great that the root would, in general, need to be of a greater diameter than the pipe. In such instances, the forces would be so great that cellular division in the root would be completely inhibited in most of the area of contact between the root and the pipe. This would then only leave the outer zone of the contact area of the root capable of applying pressure.

Image 1: There is little to no lateral movement that can be observed in this pipe even though there is no support from soil on the other side of the tree.

In soil that provides less support, such as clay, where it may be possible to push a pipe into the surrounding material, there is still an equal and opposite force being applied to the root of the tree. This, in my experience, is usually sufficient to inhibit root growth on the pipe side of the root and to result in more rapid growth on the opposite side of the pipe. This is because the root can more readily expand and push the soil away than it can push the pipe and compress all the soil that the back half of the pipe is touching.

Where roots can damage or dislodge pipes

To suggest that tree roots never damage pipes is not correct. Where roots have a diameter greater than the outside diameter of the pipe, roots may produce sufficient force to dislodge a pipe particularly if the soil is regularly approaching plasticity.

In addition, roots that enter through a join between pipes can conceivably develop sufficient surface area to move the pipe a few millimetres until it fully beds in at the next join. In the same situation, the volume of roots in the join could conceivably develop sufficient surface area that the outer collar of the pipe is broken, (the inner pipe being protected against breakage as described above)

The final way in which roots may damage pipes is raised and discussed in detail by Mattheck & Breloer[4] (1994). Essentially this occurs where a root is curved around a pipe and that root is subjected to a tensile force in turn pulling on the pipe. Mattheck raises this issue based primarily from a theoretical perspective although Mattheck has actually observed such damage (personal communication). It is perhaps important to note that Mattheck does not make mention of root damage other than by this mode.

The tensile force applied to a root is a product of a number of factors including the force applied to the canopy of the tree above ground and the cohesive strength of the soil, the number of first order lateral roots, the rate at which root division and root taper has occurred, and so on. In most cases the amount of movement in roots is quite small and the extent of movement diminishes rapidly as the distance from the tree increases.

Trees such as figs, with a high number of first order lateral roots and extensive root division are extremely stable and forces are unlikely to be of any consequence and would be of no consequence outside of the Structural Root Zone (SRZ). For a tree with a 1 metre diameter trunk the SRZ is 3.3 metres (Standards Australia 2009).

Furthermore, if conditions did exist such as those described by Mattheck, it would not be anticipated that this would affect a number of pipes rather it would be far more likely to impact on one or at the most 2 pipes and is more likely to result in the cracking of the pipe rather than the pipe being dislodged.

Contractile roots

It is import to be clear that most roots do not change their length. Young, newly forming roots, generally between 0.3 and 1.2mm in diameter do have a zone of elongation. This zone is so weak that it can often have trouble pushing roots through compacted soil and certainly do not have the capacity to shift a pipe.

The other roots that alter their length are contractile roots. These roots are found on monocots such as palms and normally found on small herbaceous plants and bulbs. Contractile roots are important in pulling these plants deeper into the soil. Trees do not have contractile roots so this could not account for pipes being dislodged.

Cement joins

It has been suggested by some plumbers that the cement[5] used to join the pipes is porous and this results in water seeping through the join and attracting roots. Whilst there is certainly truth to the fact that cement is porous the flow rate through cement is relatively low. Whilst some moisture will certainly slowly seep through cement the amount of water would be insignificant in its impact on root development.

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[4] **Mattheck C. and Breloer H.**, 1994, *The Body Language of Trees – A Handbook for Failure Analysis*, The Stationary Office, London

[5]Cement is used to mean sand and cement mix that has been mixed with water, troweled into place and allowed to set.

Even if the cement mixture was unusually porous, the slope and drainage of the pipe would result in fluids being present at the joint for relatively short periods of time. Furthermore, over time small particles and fatty compounds will tend to line the inside surface of the pipe further restricting deposits. Lastly, roots are unable to penetrate cement as is apparent by way of cement pots.

To reline, replace or maintain

Dealing with the roots

The cleaning of roots from pipes with a water jet is preferable to using an electric eel because high pressure water generally removes more of the root without causing as much damage to pipes or joints. However, cut tree roots are able to regenerate from the cut ends and it is only a matter of time before the problem of blocked drains repeats itself.

In response to this problem the plumbing industry has developed several methods to limit or prevent ingress of roots. One of these options is to fill the pipes with phytotoxic foam causing the ends of the roots to die back. In doing this the roots present are killed off to an area outside the pipe. The dead portions of the roots that remain act as a wooden plug that initially retard the entry of new roots into the pipe. As these decay, however, they create conduits that allow for new root penetration. As such this is not a suitable long term solution unless it is combined with pipe relining

Pipe relining

Another solution that is gaining popularity is to reline the pipe with a resin impregnated membrane that is inserted into the pipe and cured. This process seals the pipe entirely, restricting the egress of material into the surrounding soil and thus reducing the stimulation of root growth. In addition, the cured membrane combines with the original earthenware pipe to prevent the ingress of new roots into the pipe.

Manufacturers and installer are offering guarantees of 15 – 20 years and upwards, on such systems, with these guarantees in all likelihood, not being reflective of their potential life expectancy. Whilst a 15 year time frame may seem comparatively short, most plumbers do not provide a guarantee for PVC pipes which have a much longer life expectancy (see below).

Relining adds to the original strength of the terracotta pipes and seals the pipe with a membrane that is impermeable to water and impenetrable by pioneer roots. Because this process requires little or no excavation it makes it an ideal method to address root problems in existing services, particularly when excavation is likely to result in substantial disturbance to the existing landscape.

There are some limits to the installation of liners, in particular tight bends in the pipes, and this means that it is not always possible to reline all pipes.

Replacing pipes

The alternative option to limiting or preventing root ingress into existing pipes is to replace the pipes with new PVC pipes. Providing that these pipes are correctly bonded and installed using appropriate flexible joints and expansion joints as required it can be anticipated that these will have a normal life expectancy. When considering the life expectancy of PVC pipes. Whittle and Tennakoon[6] suggest that *'there is no reason to suppose they will not achieve upwards of 100 years' service.'*

Whilst 100 years is a long time, in human terms, it raises an important point and that is that all pipes have a finite life expectancy and just like most other inanimate objects, at some stage throughout their life they will require maintenance or repairs. In this instance the life expectancy of the earthenware pipes is much longer than the life expectancy of the cement joins.

The serviceable life of the repairs or the pipes needs to be considered in making the decision as to what option should be taken and, in cases like this, it also need to be taken into consideration when considering the apportioning of costs. Terracotta pipes with joins that start to degrade within a few decades may be replaced with a much more durable product but at a greater cost

New for old

The obvious solution may be to replace any and all terracotta pipes with new PVC pipes. If this is so, then perhaps the cost of such work should be borne by the householder who stands to benefit greatly from the upgrade. On the other hand, had the tree not been present then the householder would not need to undertake repairs to their pipework as regularly as they do with the tree present.

Both the cost and the inconvenience of the blockages caused by the roots need to be considered as does the responsibility of the householder to maintain their property, in this case the sewer pipes, in good order. In a situation like this the householder will receive the benefit of new pipes, perhaps paid in part by a third party simply because roots have blocked pipes that have not been maintained.

We may be left asking , 'When a person buys a home that is 30 years or more old, should they reasonably expect their sewers to remain maintenance free and if so would they expect that to be the case for another 15 -30 years or more'. If the answer is 'No!', then relining may be a very appropriate option. It provides a reasonable length of guaranteed serviceability and a yet to be determined period of serviceability beyond. In addition, where relining is possible it allows for repairs to be performed without, digging up and damaging surfaces, creating large amounts of mess, or damaging trees and other valuables.

Whilst there are a number of precedents in dealing with this issue the recent decisions of the Land and Environment Court frequently illustrate the principle in sharing the costs of repairs between the householder and the tree owner. In part, it would appear this is so because the householder is also benefiting from the upgrade to the pipework.

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[6] **Whittle A J. and Tennakoon J.**, 2005, *Predicting the Residual Life of PVC Sewer Pipes,* Ipswich Plastics, Rubber and Composites, Volume 34, Number 7, pp. 311-317(7)

Maintenance

Just as with all property, pipes have a finite life expectancy and require maintenance. Failing to maintain pipes in good order is, without question, the primary cause of root ingress into pipes. Many terracotta pipes are close to or past their use-by date but because we can't see the breaks or the faulty and leaking joints it takes the ingress of tree roots to remind us that maintenance is overdue.

In many cases roots in pipes should serve as a timely reminder that it is time to upgrade them. We would not think a second time about re-paining or doing an interior make-over every 10 years or even more frequently but we'll begrudge replacing or relining our drain pipes after 30 or 40 years with a product, when correctly installed that has more than double the life expectancy of the old terracotta drains.

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