TREE ROOTS IN SEWER SYSTEMS IN MALMO, SWEDEN

by Kaj Rolf and Örjan Stål

Abstract. Three sites with root intrusion problems in the City of Malmö were inspected to find different solutions to the problems. All sites had high maintenance costs due to the roots. Alternative measures for each site were selected. Each site was treated differently depending on the technical, aesthetical, cultural and economical values. At one site, pipes were relined, at another the trees were replaced with less aggressive species and at the third a decision is yet to be made.

Tree roots entering sewer systems is a well-known phenomena. To be able to live and develop, a tree must have a sufficient soil volume and a good soil environment. One reason for the good environment for root growth around pipes is the condensation or accumulation of water outside or inside the pipe. The root tip follows the pipe and penetrates where there is a weakness.

The design and type of the pipe is of utmost importance for root intrusion and the amount of root damage. Different materials can resist root intrusion differently. Older concrete pipes without rubber gaskets in the joints can resist root intrusion the least and make up the majority of pipes with root intrusion problems. Concrete pipes with rubber gaskets in the joints have been found to have a higher resistance against root intrusion but are not fully reliable, especially not in older installations. Pipes made of plastic (PVC) and fiberglass (GAP) have, so far, been nearly resistant to root intrusion, if we disregard carelessness during construction, and the joints between these types of pipes and concrete pipes. Polythene pipes (PEH) are welded so there are no joints and no problems with root intrusion. The plastic pipes must have a very well-constructed and compacted gravel bedding, to get the stability to withstand a physical load, or there is a risk for deformation and cracking, with root intrusion as a result.

Some examples of measures that reduce root intrusion are: 1) All underground installations can be located in paved areas. If this is not possible, the pipes should be laid in a pattern that least interferes with the trees. Underground installations should be concentrated in specific areas. Do not use pipes that leak. 2) Trees should be planted as far from the pipes as possible. If the tree must be placed near a pipe, use trees with less active, nonaggressive root systems. The trees should be given a well designed planting pit. 3) During construction decide whether or not a tree should be saved. If it is likely that the tree will not survive construction work, it is more economical to remove the tree immediately and replant with a new one.

The most common method of controlling roots in pipes is to cut them off inside the pipe. The root cutting is done mechanically with a knife or a steel wire around the inside walls of the pipe. Root cutting has been found to be only a temporary solution. In some areas with intense root intrusion the cutting has to be repeated every year. This leads to very high maintenance costs. The most obvious reason for regrowth of roots in the pipe may be that when the roots are pruned they form new and more numerous fine roots - this method stimulates root growth. (This is what happens when engineers develop technical methods without knowing anything about biology.)

Today there are a number of alternatives to the traditional digging and replacement of the pipe lines (5).

* *Penetryn method.* Penetryn is used to seal the leakage. It is a liquid dual-component acrylic gel that is pumped into the joints. This method can not be used where roots already have penetrated the joint.

* *Relining.* A liner of acid-resistant polyester fiber impregnated with resin is placed into the defective pipe with the help of water pressure. When the liner is in position, it is cured with hot water which gives it a rigid and hard-wearing new pipe. This is the perfect method against root intrusion.

* *Pipe sliplining.* The method involves use of 10-12 m long plastic pipe which is welded together and either drawn or pushed through the existing, defective pipe. This is a very good method that leaves no joints where roots can penetrate. In short pipe sliplining, the pipes are joined, piece by piece, with rubber rings and sockets. Since there are joints there is always a risk for root intrusion.

* *Pipe replacement.* When individual pipes are defective, they can be replaced with new pipes of the same or larger dimensions. This solves a lot of problems.

* *Chemical control* of roots within pipes is practiced in many countries but is not allowed in Sweden.

Case Study: Malmö, Sweden

Tree roots cause damage to sewer pipes. In the City of Malmö there is an annual expense of up to SEK 3 million ($ 375,000) / year because of the roots. The extent of root intrusion varies depending on the type of sewer and the type of vegetation and therefore all sites must be treated individually.

Root intrusion in sewer pipes has been well studied in the city of Malmö (1,2). The study is based on video recordings inside the pipes and provides data on root intrusions per 1000 m. Data are separated depending on age and dimension of the pipe. The most intrusions have been onto the smaller dimension pipes, 22.5 - 40 cm (Figure 1)(3), possibly because the larger dimensions are more often used as primary sewer lines or trunk sewers. These larger pipes are usually deeper in the soil and the roots may have problems growing down to them.

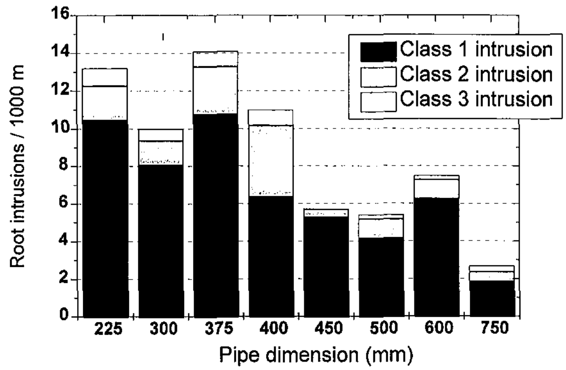

Figure 1. Root intrusion / 1000 m sewer pipe in the City of Malmö. Figures are divided into pipe dimensions.

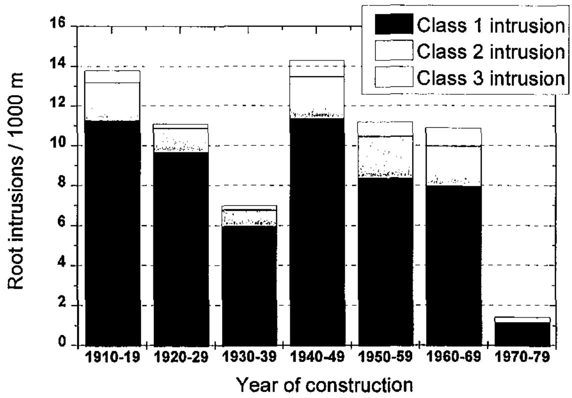

Figure 2. Root intrusion / 1000 m sewer pipe in the City of Malmö. Figures are divided into year of construction.

Data show that pipes laid down in the nineteen-fifties and earlier, with the exception of the nineteen-thirties, have the largest number of root intrusions (Figure 2)(1). During these years the sealing material was made of yarn and cement. During the war the quality of the material was poorer because of rationing. Why there were so few root intrusions in pipes from the nineteen-thirties is hard to explain. One reason may be that areas constructed during this period have not had so much vegetation near the pipes. During the nineteen-fifties the less effective plastic seals were introduced and from the nineteen-sixties to now rubber seals have been used. The large number of root intrusions in pipes from the sixties may be explained by the boom in the construction industry. Construction work had to be fast and cheap, which created negligence during the work. There is also a hypothesis that the number of root intrusions in these pipes will increase when the trees get larger.

Root intrusion. With the help of a TV-camera all pipes were inspected and the root intrusions were classified into three groups: class 1, small and few roots in the pipe but no water leakage evident; class 2, coarse roots penetrate further into the pipe and are in the water flow; class 3, large roots or numerous roots at one site.

To be able to deal with the problem of root intrusion there are today only three reasonable alternatives:

Alternative 1, root cutting. This is the most common method to remove the roots, but has been found to be an everlasting job. The problems only increase after each treatment. This alternative can be used for immediate action when the pipes are plugged with roots and must be kept open.

Alternative 2, relining. This alternative guarantees that the pipes will be free from root intrusion in the future, but the expenses are high during construction.

Alternative 3, changed design. Instead of planting trees at specific distances from each other regardless of where the pipes are situated, this alternative points at a planting design that is influenced by the location of the pipes. Firstly, there is group planting (Figure 3) where trees are planted between the pipes, and secondly there is row planting (Figure 4) where different species are placed according to how aggressive the root system is. This places extra demands on the landscape architect to create a good design to use the right trees at the right places.

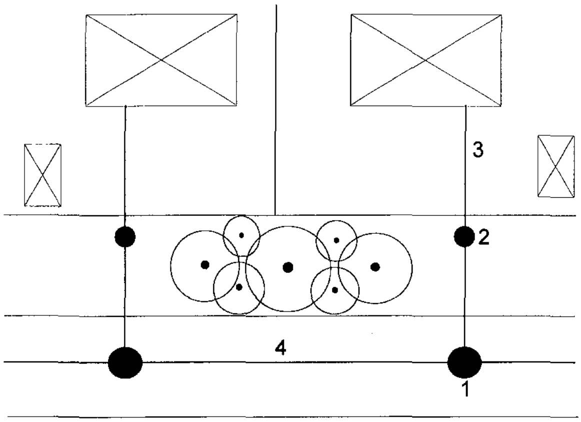

Figure 3. Trees are planted in groups to avoid planting near the service connections. The numerals represent :1. Manhole, 2. Inspection well, 3. Service connection, 4. Main sewer line.

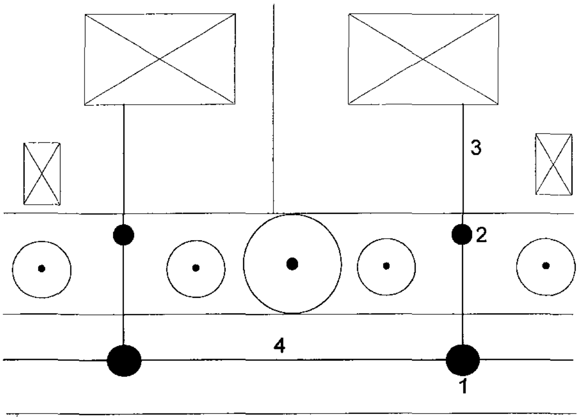

Figure 4. Trees are planted in a row but with non-aggressive species near the service connections. The numerals represent: 1. Manhole, 2. Inspection well, 3. Service connection, 4. Main sewer line.

Materials and Methods

With the assistance of City of Malmö authorities three sites with root intrusion in sewer pipes were chosen. All sites have had major problems with roots and the costs for maintenance have increased during the years.

The following procedures were carried out on each site:

1. The current root intrusion problem was assessed..
2. Remedial conditions and costs were summarized.
3. A field investigation of soil conditions and plant species was conducted.
4. Plant values were appraised.
5. Suggestions were offered on different solutions: economical, technical and aesthetical consequences were compared.
6. Solutions were discussed with all parties involved.
7. Decision was made on measures to be taken.

The sites were:

I. Vanåsgatan from number 77 to 175. Vanåsgatan is the street in Malmö that has had the highest maintenance costs / meter of line *during the last five years due to root intrusion in the* sewer pipes. It is in a housing area built in the late nineteen-forties and early nineteen-fifties with a combined sewer system of concrete.

Trees: white willow, *Salix alba*. All willow trees were between 35 and 40 years old, with a stem circumference of 90 - 120 cm. Willow is the species that causes the most problems with root intrusion in sewer and drain systems. The trees were growing in a grassed area between the street and the private gardens (Figure 5). The trees were growing close to the sewer pipes and in some cases even immediately above the pipe.

The sewer system was built in 1948 -1956. The pipes are made of concrete and the joints were sealed with yarn and cement. This means that tree roots easily can penetrate the joints. The maintenance costs were calculated to SEK 186 ($ 23.50) / meter each year. To that sum should be added the amount the residents had to pay for cleaning their own service connections.

The soil. There were no actual planting pits for the trees. There was a 25 - 30 cm thick top soil layer and below the top soil there was a heavily compacted clay subsoil. The roots grew horizontally along the compacted subsoil surface and down in the less compacted pipe trench.

II. Rödkullastigen from number 3 to 9. Rödkullastigen is a housing area with high-rise buildings and large green open spaces with bicycle paths. Along one bicycle path, several smooth-leaved elms are growing (Figure 6). The main sewer pipe is located in this road. There are no immediate problems with root intrusion, mainly due to the big size of the sewer line. Service connections were located 1-2 meters from the trees and the sewer line was located 3-4 meters from the trees.

Figure 5. The street Vanåsgatan was built in the late nineteen-forties with a combined sewer system made of concrete. The trees were growing in a grassed area between the street and the private gardens.

Trees: smooth-leaved elm, *Ulmus carpinifolia* 'Hoersholmii'. All elm trees were between 30 and 40 years old. Elms are relatively fast-growing and can be fairly old. The root system is wide and rather extensive but much less aggressive than willows and poplars. Old elm trees have a large root system that may cause problems with root intrusion.

The sewer system was built in 1958. Both the sewer line and the service connection are made of concrete. The pipe dimension was 22.5 cm in diameter and the joints were sealed with yarn and cement. Tree roots could easily penetrate the joints. The maintenance costs were calculated to SEK 97 ($ 12) / meter each year.

The soil. Each tree had a planting pit of 7 m^2. The depth of the pit was 70 cm over a non-compacted subsoil. The surrounding grassed area had a 25 - 30 cm thick top soil layer.

III. Kungshällagatan from number 55 to 61.

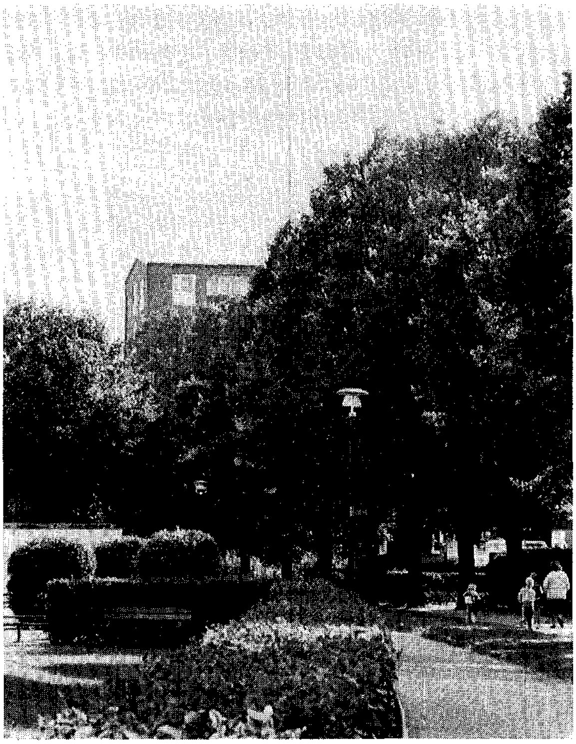

Figure 6. Rödkullastigen is a housing area with high-rise buildings and large green open spaces with bicycle roads. Several smooth-leaved elms are growing along one of the bicycle paths.

Kungshällagatan is a street in a residential area built between 1954 and 1956. The sewer line is a combined sewer located in the middle of the street. Unlike the other two areas, the problems in this area are caused by trees growing on private property (Figure 7). The part of the street that had the most severe root intrusion is a section about 80 m long. Along this section there are some large birches in the private gardens. This means that the service connections were 2-4 meters and the sewer line was 4 meters from the trees.

Trees: common birch, *Betula pendula* . In the private gardens there were several different species but at the places where root intrusion occurred, common silver birches aged 30-35 years old were growing. The root system is rather intensive and often stays close to the stem but in less favorable soil conditions the root system can be wide-spread.

The sewer line was 22.5 cm in diameter and the service connection 15 cm in diameter. The pipes are made of concrete and the joints were sealed with yarn and cement. Tree roots can easily penetrate the joints. The maintenance costs were calculated to SEK 90 ($ 11) / meter each year.

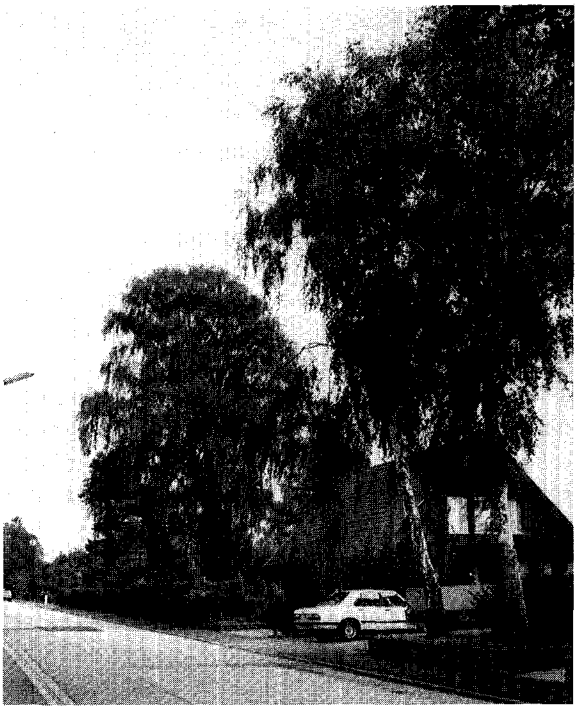

Figure 7. Kungshällagatan is a street built between 1954 and 1956. The sewer line is a combined sewer located in the middle of the street. The problems in this area were caused by trees growing on private property.

The soil. Since the trees were on private property, no actual soil examination was made. The trees were very close to the street and tree roots must have followed the pipe trench out into the street.

Results and Discussion

Site 1, Vanåsgatan.

Alternative 1. The pipes at Vanåsgatan required extensive treatment either now or in the near future. They had been in a routine maintenance program including high pressure flushing of the service connections. This program gave only temporary protection against root problems. After the roots had been cut, they quickly developed a new fibrous root system. This is a costly procedure.

Alternative 2, relining. This alternative guarantees that the pipes will be free from root intrusion, but the construction required heavy expenses, SEK 1575 ($ 200) / meter of line. There would also be an expense for the private house-owners since the relining must be done all the way to the house. Otherwise, there is a risk that roots will penetrate the joint between the old and new systems. After 7.5 years, the expense would have paid for itself since the routine maintenance costs will have been eliminated. The advantage of this alternative is that you retain the character of the street with the willow trees.

Alternative 3, changed design. A new design with new trees would cost SEK 850 ($ 105) / m^2. This means that the costs will be paid after 6 years compared with the present maintenance program.

Decision, use alternative 3. This meant that all willows were taken down and new trees were planted. The species chosen were maple, *Acer platanoides* 'Schwedleri' where there was enough space and *Cercidiphyllum japonicum* and *Prunus sargentti* in groups according to Figure 8, which shows the street one year after replanting.

Site 2, Rödkullastigen. When deciding measures for this area a lot of attention was paid to the aesthetic value of the trees. These large elms were essential for this area. To change the vegetation here would have received a negative im-

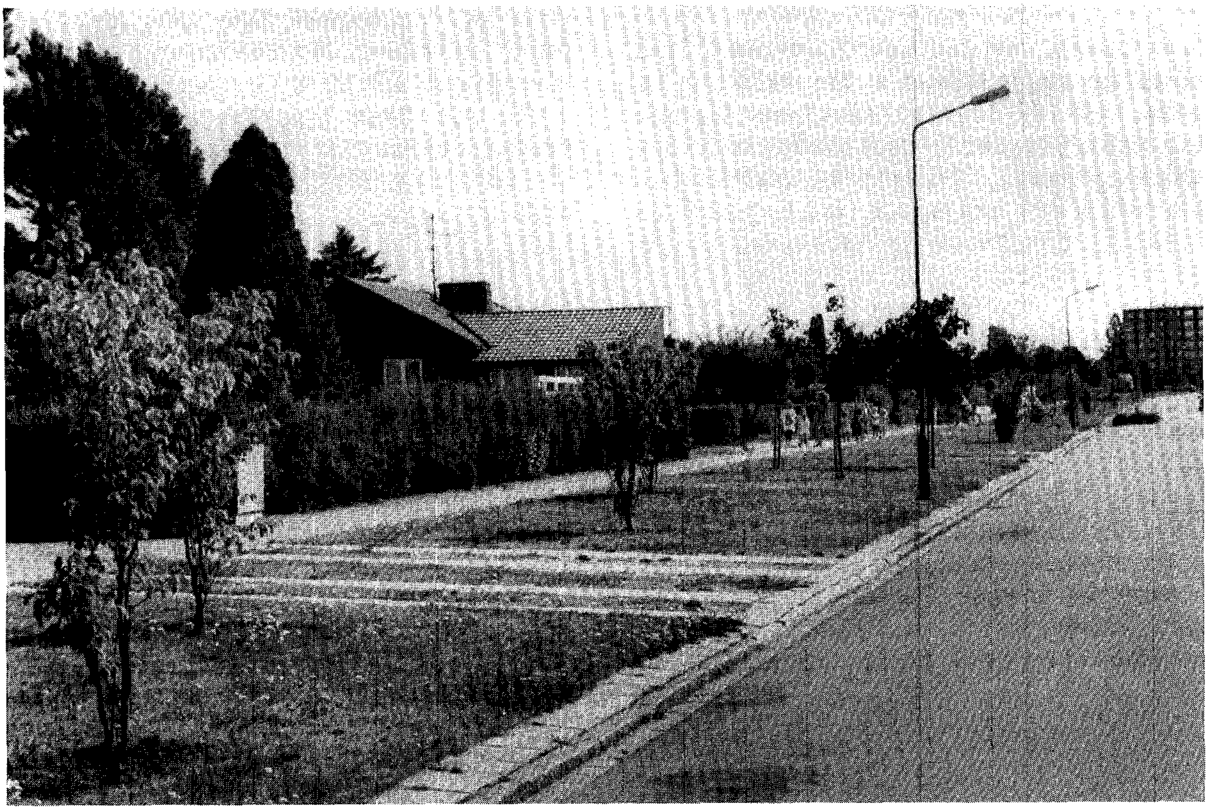

Figure 8. Vanåsgatan one year after replanting with Acer platanoides 'Schwedleri' where there was enough space and with Cercidiphyllum japonicum and Prunus sargentti.

pact from the residents.

Alternative 1, root cutting. The pipes at Rödkullastigen needed treatment now or in the near future. They were in the routine maintenance program.

Alternative 2, pipe cracking (a). This alternative requires rehabilitation of the old pipes and or alternative (b), relining. This alternative guarantees that the pipes will be free from root intrusion and will cost SEK 1369 ($ 170) / meter.

Alternative 3, changed design. This was not a realistic alternative at this site since the trees in their present condition were too valuable for the living environment.

Decision, use alternative 2b.

Site 3, Kungshällagatan. It is considerably more difficult to find good alternative measures when the trees are on private property. Since the homeowners also own the trees they cannot be removed without the homeowners' permission. If the homeowner has had no problems with root intrusion in the service connection, it is hard to convince him to remove the tree. On the other hand, if he has had expenses he is often willing to get rid of both the tree and the expenses.

The same type of problem arises if there is a decision to reline the pipe. If the sewer line is relined, the best way is to reline the service connection as well, otherwise roots will penetrate the joints between the old service connection and get into the new sewer line. The problem is that the expenses for relining the service connection must be paid by the house-owner.

Alternatives 1. Keep on with the present measures and accept the costs. If the costs rise in the future this alternative is not realistic.

Alternative 2. Inform the homeowners of the present situation and how it may develop in the near future. Present the different alternative measures and try to convince the homeowners that the pipes must be rehabilitated, otherwise the expenses will grow bigger for every year that passes.

Decision, none at this time.

Summary

Three sites in the City of Malmö were inspected to find alternative measures for each site. At each site the technical, aesthetical, cultural and economical values were assessed. At one site with willows the trees were replaced with less aggressive species and the expenses were shared between the wastewater works and the park department. At another site the aesthetical value was so high that the pipes were relined with a material that eliminates root intrusion problems in the future. At the third site, where trees were growing on private ground, a decision has not been made since the homeowners have to share the expense of relining or taking the trees away.

During this project there was always discussion between the water works and the park department when a decision was made. This is a prerequisite for good solutions to the problem.

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Literature Cited

1. Lidström, V. 1994. Change in structural condition in sewer pipes. Proceedings NODIG 94, Copenhagen, June 1994.
2. Stahre, P., A-C Sundahl and V. Lidström. 1994. Va-ledningars kondition. Va-Forsk rapport 199401.
3. Stål, Ö. 1992. Trädrötter och ledningar (Roots and pipes). Svenska vatten- och avloppsverksföreningen, VAV. Report 1992-14. (in Swedish)
4. Stål, Ö. 1992. TrÑdrîtter och ledningar (Roots and pipes). Svenska vatten- och avloppsverksfîreningen, VAV. Report 1992-14. (in Swedish)
5. VAV, 1989. VAV Publikation P66. Svenska vatten- och avloppsverksfîreningen. Stockholm. (in Swedish)

The Swedish University of Agricultural Sciences,
Department of Agricultural Engineering,
Section of Horticultural Engineering,
Box 66,
S-230 53 Alnarp
Sweden