FOREWORD
This handbook was produced on the initiative of the City of Stockholm through Björn Embrén. The aim of the handbook is to communicate information, particularly to contractors, about conditions for urban trees. One of the specific objectives is to describe a technique for improving the growing conditions for trees. The handbook describes the principles of different operations, standard designs and methods for planting new trees and for plant bed renovation for trees in Stockholm.

(Cover photo: Örjan Stål)

Working group
Björn Embrén, Traffic Department, City of Stockholm
Britt-Marie Alvem, Traffic Department, City of Stockholm
Örjan Stål, VIÖS AB
Alf Orvesten, LAND Arkitektur AB

Reference group
Anna Hedlund, SWECO
Rune Bengtsson, SLU Alnarp
Tobias Emilsson, SLU Alnarp
Eva-Lou Gustavsson, SLU Alnarp
Liselott Johansson, Trafikkontoret City of Stockholm
Anders Ohlsson-Sjöberg, Arbor Konsult
Folke Kvarnström, Röda Träden
Bo Ekbom, Röda Träden
7 SAMPLE CASES WITH DRAWINGS, PLANT BED RENOVATION
7.1 Small trees with poor growth 48
7.2 Large street trees with shallow root system 50
7.3 Large trees - situations with build-up soil 54
7.4 Large trees - replacement of compacted and/or low nutrient soil 59
7.5 Operations in existing structural soil - excavation and backfilling 62
7.6 Protection of tree roots – root wrapping 64

8 DESCRIPTIONS

9 APPENDICES
9.1 Planting soil type A 75
9.2 Planting soil type B 76
9.3 Planting soil type C 77
9.4 Planting soil type D 78
9.5 Particle size distribution curve - fraction for aerated bearing layers 79
9.6 Particle size distribution curve – structural fraction (MISSING) 80
9.7 Example – Assessment table, compensation for damage to trees 81
9.8 Checklist for construction foreman – monitoring programme 82
9.9 Structural soil – Description of procedure short version 83
PLANTING BEDS IN THE CITY OF STOCKHOLM
A handbook
The presence of trees in the city is taken for granted by many people and trees are generally an appreciated component of the urban environment. However, the living conditions for urban trees are often difficult. A number of aspects of growing conditions are different for trees in the city compared with trees in natural environments, e.g. microclimate and access to water, nutrients and air. Other factors are that trees in the city are difficult to maintain and are often subjected to damage, e.g. vehicle impacts, etc. The focus in this handbook is on describing how tree roots grow and develop in urban environments. Research has shown that soil conditions are of central importance for the establishment, development and survival of trees in the city.

In this handbook, urban trees are divided into two categories, park trees and street trees. Park trees are defined by being planted in large green areas where their growing environment still differs significantly from that of trees in natural environments. The growing environment of street trees is defined by the presence of paved surfaces in the immediate vicinity of the trees. Park trees generally have better soil conditions than street trees. In existing park areas with a relatively unaltered soil profile, where water, nutrient and air transport is functioning, trees have good conditions for development. It is important to study these naturalistic soil conditions before new plantings. The existing soil structure in park areas is often the best planting soil. It should not be replaced as a matter of course.

Cities contain many green areas established on soils with a severely altered soil profile, such as former vehicle routes, ramped up areas, etc. Park trees planted in sites with a disturbed soil profile can often display similar problems to street trees in paved areas and should therefore be regarded more as street trees than park trees.

In terms of facts, this handbook is based partly on the results of scientific studies on trees, soil and technical infrastructure and partly on many years of practical experience regarding studies of tree root systems in the urban context. A large proportion of the background facts and suggested remedial measures are taken from Germany, which has more than 20 years of experience of this type of problem. For this reason, certain modifications have been made to AMA Installation 07.
1.1 Instructions for use

This handbook uses text and drawings to describe examples of different practical approaches for improving the growing conditions for urban trees. The handbook is directed at all those designing, building and maintaining environments containing trees.

The handbook is divided into two parts, one of text and one of sample cases. The text section comprises Sections 1-5 of the handbook and is mainly directed at those wishing to study in greater depth the subject ‘conditions for urban trees’. The text provides a guide to e.g. soil science, biology and various practical courses of action.

The part with sample cases, Sections 6-8, is more instructive in its nature and describes a range of sample cases illustrating practical solutions for more or less general problem situations for urban trees. The various solutions are reported in the form of short descriptive texts on e.g. work procedures, with cross-sectional drawings for soil construction. Section 8 provides suggestions for texts for bulk descriptions.

The technical drawings presented in the sample case section are taken from actual projects commissioned by the City of Stockholm. The drawings in the handbook form part of the technical manual for the City of Stockholm. The examples in this publication can and should naturally be used as inspiration for problem-solving in other parts of the country. However, each new situation requires different degrees of adaptation in its solutions, so the examples given here should be regarded as idea-generating principles rather than as absolute complete solutions. The handbook is based around the specific conditions prevailing in Stockholm. This means that the proposed remedial measures and solutions presented in this publication are specifically adapted to these conditions and to the official requirements of the City of Stockholm. This should be borne in mind when applying the solutions in the handbook to regions other than Sweden.

The handbook concludes with appendices in Section 9.

The idea is that these texts, drawings and appendices can be used when drawing up invitations for tender and as support on-site during the construction phase.

1.2 Problems for urban trees

The problems encountered by urban trees are many. There follows a brief description of the most common problems.

Lack of space

Plant beds with a restricted rootable volume inhibit tree development. Trees often only have access to a very limited volume around the trunk. In addition, older trees often have their rootable volume limited or reduced over the years due to soil excavation work, e.g. the laying of new pipes or cables below the ground.
BACKGROUND

Lack of oxygen
Access to oxygen in the soil is the single most critical factor for the wellbeing of urban trees. Dense surface layers and great variations in structure in the soil profile contribute to oxygen deficiency and carbon dioxide poisoning of tree roots. Soil compaction and structural variations can also lead to standing water, which in turn lead to oxygen deficiency.

Lack of water
Lack of water is another severe problem for urban trees, since they are often surrounded by paved surfaces. Rainwater is diverted away from paved surfaces to stormwater drains and not down into the soil. During the construction phase, compacted layers and sharp structural differences are often created in the soil in the vicinity of the trees, which impedes water transport into the soil.

Lack of organic material
The paved surfaces around many trees prevent addition of any further organic material, which in the long term leads to nutrient deficiency. The biological activity in the soil is low in such environments. Grassed areas do not contribute much organic material either, but instead compete with the trees for water and nutrients. This is particularly significant when the trees are young.

Salt damage
Salt damage to trees is caused by the large amounts of salt used to prevent slip during the winter. This salt is spread on roads and pavements and in some cases it can reach toxic concentrations. However, it is more common for the salt to cause collapse of pores in the soil, which leads to damage in the form of oxygen or water deficiency or standing water. This compacted soil situation prevents salt in the soil being transported away with rainwater.

Pruning damage
Pruning damage is common on trees in the city. One of the most serious forms of damage arises due to severe cuts on the main trunk or branches causing rots, resulting in falling branches. If damaged branches and roots are not pruned in the correct way after digging work, this can give rise to rots and fungal attacks on the tree.

Physical damage
Many of the trees standing close to local roads have damage to trunk and crown. Grass cutting can also often cause impact damage to trees. The area under trees is not infrequently used as an extra driving route and parking place, which can cause damage to trunk and crown and soil compaction. Repeated digging around trees means constant infliction of new damage to the root system, creating entry points for rots and fungal infections. There is seldom anything done to protect exposed roots during digging and damaged roots are often left unpruned.
Conflicts with pipelines
In most places in the city there is great competition for space in the soil, which often leads to conflicts of interest between tree requirements for growing volume and underground installations. The two most common points of conflict are tree roots causing blockages in sewers and drains and existing trees being severely damaged by the installation, repair and maintenance of pipes. This means that tree placement in relation to pipelines is a very important aspect of urban design. The establishment of new trees on the same site as large old trees can also be difficult or even impossible, since the conditions in the soil will have changed since the original trees were planted.

1.3 How can old street trees exist in such tough conditions?
The large trees found today in cities were often established under completely different conditions for growth than those existing at the site at the present time. Old trees have been growing and developing for a long time. In the past, pavements were generally made from a thinner layer of stones and gravel than today. In some cases, pavements were laid directly on lightly compressed soil. Roots could more easily satisfy their requirements with this type of surface structure than with the current extremely compact and dense surface coverings. This is one possible explanation why some trees seem to ‘thrive’ in paved environments. The effects of changes in soil structure only appear in large trees after 10 or 20 years. In some cases, even damage to the roots may not cause visible effects in the tree crown.

1.4 Shape and spread of tree roots
The spread of tree roots is generally described as the root mass being as large as the crown volume. It is also claimed that tree roots extend from the centre of the trunk out to the drip line of the crown and that the roots do not grow deeper than 2.5 metres. However recent research shows that these theories must be strongly questioned for urban growing environments. The concept of heart root, taproot and sink root are stages of development of the root system that are only relevant during the first 10 years of the tree’s development phase. Tree roots grow and take their shape after the prevailing conditions in the soil. Tree roots grow where they can obtain the optimum conditions for growth, i.e. good access to nutrients, water and oxygen. The majority of tree roots can therefore be found far outside the drip line of the crown. For the same reason, trees can develop an extremely one-sided root system. In natural environments tree roots are generally in the upper layer of the soil but depending on soil conditions and specific requirements, they can be either deep or shallow. In paved environments, tree roots are seldom shallow. It is common for roots to grow to 3 m depth or more. For this reason, thorough investigations must always be carried out before excavation work is started in the vicinity of existing trees. Such investigations should include one or more test holes (see section 4.2). A decision can then be made on the most suitable excavation method for the area. In the long run, this makes the work more cost-effective while minimising damage to trees.
1.5 Soil conditions
The soil conditions for urban trees can be summarised as follows:

- The volume of the plant bed is too small.
- Dense paving or compacted soil contributes to oxygen deficiency and carbon dioxide poisoning of tree roots. Oxygen deficiency mainly arises due to excess water not draining away. Dense paving and compacted soil can also lead to water deficiency.
- Salt damage. Poor permeability in the soil profile causes more severe salt damage since the salt cannot be washed out and is instead concentrated in the soil.
- Lack of additional organic material contributes to nutrient deficiency and a low incidence of soil organisms and bacteria that are important for trees.
- Technical incursions in the soil close to tree root systems, such as excavation, carry a risk of direct physical damage in the form of torn roots, but also indirect damage through soil compaction (heavy machinery and building equipment).

Schematic view of a common situation for many urban trees. The paved surface causes the root system to extent one-sidedly under the park surface. Physical damage is caused to root and crown by repeated digging close to the tree. Vehicles cause physical damage to tree crown and trunk. (Illustration: SWECO)
In discussions about planting beds there are often a number of technical terms involved. These include concepts such as planting soil, mineral soil, texture, structure, particle size distribution, humus content and nutrient status. Structure refers to the distribution of pores in the soil. Large pores provide the soil with air, while small pores generally contain water. When soil is compacted, it is the large pores that collapse and thus compaction damage leads to a decreased supply of oxygen. Analysis of soil composition is usually presented in a graph called the particle size distribution curve. This graph shows the percentage distribution by weight of the different size fractions of soil particles, added together in the curve with one fraction placed beside the next in the curve. The size of a particular fraction, e.g. fine silt, is read from the particle size distribution graph as the value where the line cuts the upper boundary for that fraction, for fine silt 0.006 mm.

In this handbook we use the concepts planting soil and mineral soil. By planting soil we mean the upper humus-rich part of the soil profile. Unless otherwise stated, this refers to the upper 400 mm. By mineral soil we mean the soil under the planting soil. The only difference to the planting soil is that mineral soil is humus-poor. When constructing planting beds for trees, both planting soil and mineral soil may need to be added.

Humus is the organic component of the soil and consists of fallen leaves, branches, peat, dead animals, etc. The humus content is important for the structure of the soil and contributes to soil nutrient and water retention properties. In analysis of humus content, the organic matter content of the soil is given as a percentage by weight. However such analysis gives no actual information about the quality of the organic material present. The easily decomposed sphagnum peat frequently used in artificial soil acts as a structure improver and leaves the soil well aerated in the early years. However, around 80% of sphagnum peat is broken down after a few years and only the stable fractions remain. Therefore in a planting soil with an original peat content of 6%, only around 1% of this remains after a few years, at which time the nutrient content, structure and water-holding properties of artificial planting soil will have deteriorated. Addition of organic matter after planting is thus an important measure where this is possible.

A good method is to mulch, i.e. place organic material such as park compost around trees planted in vegetation areas. Worms and microorganisms break down the material and increase the humus content of the soil. For trees in paved areas it is often difficult to add humus after planting.

Nutrient status is a concept that describes the concentrations of different nutrients in the soil. The nutrient status is determined by chemical analyses of the soil. There are several methods for analysing the nutrient status. For the guidelines given in this handbook, the AL method is used. AMA Infrastructure 07, Advice and Instructions Table RA DCL/1, show the levels and distribution of nutrients that experience has shown to be good underlying values in a planting soil. It is these that are recommended for planting soil in this handbook.
A common problem in tree planting is that the planting soil and mineral soil added differ considerably in texture. In the worst case scenario, the mineral soil can be coarse rock aggregates. These aggregates, which are unsuitable for planting beds, can often meet the requirements for mineral soil according to AMA Installation 07. In order to provide the best possible conditions for tree roots, the planting bed should instead consist of a homogeneous soil where the particle size distribution should not deviate in different layers. However, the humus content should be low below > 400 mm depth (max. 2% by wt.). If the soil is applied in layers with distinct textural differences, this creates capillarity-breaking layers in the planting bed, which can lead to excess water being prevented from draining away or soil water not being transported up to roots. This can lead to oxygen and water deficiency for the tree.

In other words, the optimal solution is to construct planting beds with a homogeneous texture where the upper part (down to 400 mm) is humus-enriched and where the lower part is in principle humus-free. This resembles a natural soil texture. In planting beds where the naturally created soil texture is altered or where there is simply no original soil, it is considerably more difficult to create a homogeneous planting bed with a lower humus content under 400 mm depth. It is often difficult to obtain large quantities of humus-free mineral soil that has the same texture as humus-rich planting soil, but some of the larger soil producers have started to manufacture mineral soil with the same particle size distribution as the associated planting soil.

2.1 Trees in vegetation areas, naturalistic soil profile

Old park soil is often a very good environment for establishing new trees. Undisturbed old park soil has actively functioning biological life with a good humus content and functioning air and water transport in the soil profile. This can naturally be exploited in tree planting. Prior to tree planting, a study is made of conditions at the site, e.g. texture, structure, soil status, microclimate and light conditions. These conditions are weighed up and form the basis for choice of tree species and planting procedure.

When planting in existing soil, the nutrient status is often low. Therefore soil samples should be taken and fertilisation should be based on the results. To promote establishment of the trees, the structure of the soil should be improved with humus and mature compost. In sandy and light soil profiles, humus can be mixed in fairly deeply without problems (max. 600 mm). As regards clayey soils, care must be taken during incorporation of humus and compost deep in the profile. Decomposition is taken care of by e.g. earthworms, which improves the structure of the soil. A rotavator should NOT be used on clayey soils, since it destroy soil aggregates and the structure of the soil. For the same reason, great care is needed when compost is applied in rainy weather.

In many cases, a small volume of new planting soil is needed in these conditions. However, the aim should be to apply compost or mulch (to a min. depth of 150 mm) in a 1-2 m radius around the tree in order to stimulate biological activity in and around the root system of the new tree. It should be noted here that decomposition of some mulches, for example coarse bark chippings,
competes with the nitrogen requirements of the tree. An extra dose of nitrogen with such mulches is therefore a good rule.

2.2 Trees in vegetation areas, disturbed soil profile

Trees in vegetation areas with a disturbed soil profile are a commonly occurring problem in urban environments. Many green areas are constructed completely artificially, with park areas being created with volumes of soil transported to the site. These volumes of soil are often excavation spoil from different parts of the construction project. For this reason, terrace and soil masses can often vary in quality and different layers can be created in the planting bed. Under such conditions, trees can have very poor growing conditions.

Textural differences often arise between mineral soil and planting soil. In many cases there is not even any mineral soil and instead the layer of planting soil is placed directly on the backfill, which in the worst case consists of compacted aggregate material or old building rubble. These types of materials are unsuitable as a growth substrate for tree roots. Sharp transitions can easily be created between the texture and structure of different soils in the soil profile, which can lead to rainwater remaining standing in the upper part of the soil profile (leading to oxygen deficiency) and water being prevented from being transported upwards in the soil profile (leading to drought). Another common problem is for planting soil to be applied in too thin a layer, e.g. 100-200 mm compared with the recommended 400 mm. This together with the above-mentioned problem of large variations in texture (e.g. clay soil laid on sandy soil or gravel) gives extremely poor conditions for tree planting.

Physical compaction is another common reason for profile damage, i.e. the soil where the trees are to be planted being trafficked during construction, parking, etc. This impairs the ability of the soil to function as a growing environment.

2.3 Trees in paved areas

Trees in paved areas are surrounded completely or mainly by pavements. These surfaces have to cope with carrying traffic but having some greenery in the environment is desirable. This requires specialist bridging structures and planting beds. To allow trees to develop into attractive elements in these environments, so-called structural soils have been developed. A structural soil is a volume of coarse, homogenous crushed rock (100-150 mm) containing around 30% pores filled with air and water and nutrient-retaining soil, planting soil type D (see Appendix 9.4). Therefore, this soil construction consists of two parts, the crushed rock structural skeleton and the planting soil. Care must be taken to ensure that these two components are handled separated during construction (see Appendix 9.5).

For trees planted in paved areas, it is particularly important to provide good growing conditions. Structural soil is used to safeguard tree establishment and to avoid damage by roots to paving or underground pipes. By using specialist planting beds in the form of structural soil
or plant beds in culverts designed for tree roots, a rootable volume can be created. Structural soil must guarantee a good rooting space while also meeting the demands on bearing capacity for heavy traffic. These criteria can be fulfilled through compressing the structural material in layers and then pouring the planting soil down between the stones. Such pouring of planting soil is only possible when the clay content is below 8% by weight.

The specialist planting bed must be placed in direct contact with the planting soil in the planting hole. The structural soil can also form a connection between the planting hole and adjoining green areas in which the roots are given even better conditions for growth.

A structural soil contains only 1/3 planting soil and therefore the structural soil construction requires additional watering during dry spells in the most intensive growing period of the tree. To compensate for this disadvantage and increase the water-holding capacity, pumice (2-8 mm fraction) can be used. Pumice as a bearing material has the unique property of also being able to retain plant-available water.

2.4 Stormwater as a resource
Cities contain large paved areas. Rainwater, or stormwater, from paved surfaces is often conducted directly into storm drains and dealt with by the sewer system. The expansion of cities means that increasing amounts of stormwater must be handled. This problem is often apparent after heavy rain, when flooding can ensue. In such cases, urban plant environments could often absorb some of the stormwater from paved surfaces and delay its progress to drains, thus decreasing the pressure on the existing drainage system.

Considering the vulnerable situation of urban trees, it is important to try to use every opportunity to improve the environment of these trees. One such opportunity is to manage stormwater locally in plant beds. This gives a number of positive effects. Since the water is diverted to plant beds and managed locally, the load on the city’s drain system is lowered. The stormwater helps to improve the living environment of the trees, which e.g. decreases root intrusion into underground pipes.

Trees take up large amounts of water from the soil during the growing season. For example, measurements from a fully grown lime tree (crown diameter approx. 14 m) in Malmö in summer 2006 showed that that particular tree consumed around 670 litres of water per day during the month of July. Therefore trees have a huge capacity to handle storm water.

However, diverting stormwater to urban tree plant beds is not without risks. The soil must have a good capacity for drainage and it must be possible to conduct all excess water out of the plant bed. Too much water fills up the air pores in the soil, leading to oxygen deficiency for the trees. Soils with a high clay and silt content are not suitable for use in infiltration of stormwater. The use of salt to combat slip on pavements in winter exposes many urban trees to high salt concentrations in the soil. High concentrations of sodium ions in soils with a high...
clay content cause pores to clog up, resulting in oxygen deficiency. Therefore in situations with high clay contents, care is needed when diverting stormwater from areas with solid pavements. In situations where the residence time for water is low, such as in sand- and gravel-dominated soils, see planting soil type B, the soil is easily flushed out of the soil and the risk of the salt negatively affecting the trees is small.

Diverting stormwater into plant beds alters the growing conditions. In new planting, it is possible to adjust the plant material to the given soil conditions. In situations with large amounts of stormwater, the tree species chosen should therefore require, or be able to tolerate, much water. In cases where the trees can be subjected to high concentrations of road salt, the soil must be gravel- and sand-dominated. Such soils have a weaker water-holding and nutrient-buffering capacity, so drought-resistant species requiring low levels of nutrients should be used.

For existing plant beds, the possible consequences must be carefully considered before a decision is made to divert stormwater into them. The stormwater can be a good help but can sometimes do more harm than good.

2.5 Artificial soil for urban trees

The following general criteria apply for a planting bed profile consisting of artificial planting soil:

- The soil in the planting beds must be homogeneous throughout the entire profile, i.e. there should not be any great differences in texture between the planting soil and the mineral soil. This must be taken into consideration when drawing up instruction texts relating to AMA Installation 07.

- To obtain a stable and durable structure in the planting soil, the texture must be rather homogeneous, i.e. more graded than ungraded.

- The planting soil must have a humus content of 5-8 wt-% to a depth of 400 mm. Mineral soil, at depths > 400 mm, must have a humus content of < 2 wt-%.

- All planting soil must meet the general requirements on nutrient status according to AMA Installation 07 Table RA DCL/1 (see section 2).

Samples must always be taken from soils for tree planting and the nutrient status analysed by a laboratory specialising in planting soil analyses. The results of these analyses determine the starting fertiliser applied before planting. Soil samples must be taken regardless of whether there is existing soil at the site or whether artificial soil is being used. The soil analyses also show the particle size distribution.
Soils for four typical planting situations

The four planting soils listed below are recommended for different areas of use. These four soil type classifications are designed for use when ordering artificial planting soil and as a guide in evaluating soil samples. Section 9 contains the particle size distribution curves for these soils. Suitable particle size distribution is indicated by a green band that shows the approved range of particle size distribution for the respective soil type. An approved soil should therefore have a particle size distribution curve that fits within the green band.

**Planting soil type A**

**Planting soil for normal soil conditions**

Planting soil type A is the planting soil recommended for normal soil situations. The soil has quite a high clay content, which provides good nutrient- and water-holding capacity. It is this soil that is used most frequently in planting areas (see Appendix 9.1). This soil is not suitable for shallow constructions and on gravelled terraces because the profile can easily become waterlogged.

**Planting soil type B**

**Planting soil for salty soil environments**

Planting soil type B is intended for situations where the growing site is subjected to large amounts of de-icing salt. The clay content of this planting soil is low since the pores in clay soil tend to disintegrate at high salt concentrations. This soil has poor water- and nutrient-holding capacity, so the maintenance intensity for watering and fertilisation must be extra high. Trees planted in this soil should be drought-tolerant and have low nutrient requirements (see Appendix 9.2).

**Planting soil type C**

**Pumice-based planting soil**

Pumice-based planting soil type C is recommended for planting beds established above a basement where there are demands for low weight load or in other extreme growing environments requiring shallow constructions for planting beds. This soil should consist of at least 40% pumice. Pumice is a low-weight, air- and water-holding mineral. This soil gives good establishment results for trees in paved areas. It is therefore recommended for use as planting soil in planting holes (see Appendix 9.3).

**Planting soil type D**

**Planting soil suitable for structural soil (can be used in entire planting bed profile)**

Planting soil in structural soil is designed so that the material can be washed down into the structural base. The soil contains a certain amount of clay and humus to maintain the water- and nutrient-holding capacity. However this soil has a lower water- and nutrient-holding capacity than type A, but higher than type B. In small areas, planting soil type D can be used in the entire profile, e.g. since it can be difficult to order small quantities of different soil types (see Appendix 9.4).
3 NEW PLANTING

The conditions for planting urban trees are often very variable. Planting in street situations differs markedly from planting in park areas. However, the conditions for park trees can also be very variable in urban environments. We have therefore divided planting of park trees into two situations, trees in vegetation areas with a naturalistic soil profile and trees in vegetation areas with a disturbed soil profile. In situations with trees in a disturbed soil profile, the growing conditions resemble those in paved areas. This requires specialist planting beds in order to give the trees good opportunities for growth and establishment.

Planning before planting

The extreme situation of urban trees places great demands on planning and upkeep. Establishing and maintaining urban trees is expensive. We would like to draw attention to the following points, which should be considered before planting:

• Plan for trees where suitable conditions are provided. Don’t plant trees otherwise.
• Select tree species on the basis of their specific requirements in relation to growing site.
• If possible, adapt the planting bed to the requirements of the tree species selected.
• Create good conditions for functioning gas exchange in the soil. This fulfils tree root requirements for oxygen uptake and carbon dioxide release.
• Create the conditions for future fertilising and addition of organic material to the planting bed.
• Use structural soil as a support under paved surfaces.
• Create permeability in the soil and if possible infiltrate stormwater into the planting bed.
• Drain the planting bed. The possibility for removing excess water from the planting bed must be provided, particularly on dense clay soils.
3.1 Trees in vegetation areas, naturalistic soil profile

With new planting in existing park areas, attention should be paid to the soil conditions present at the site. Old, undisturbed park soil is often the planting soil. Provided that the soil properties are not destroyed, e.g. through physical compaction, it is often good to plant in the soil found at the site. In existing soil situations, there is a risk of analysis revealing that the soil properties deviate from the specifications listed here for planting soil. It is important to point out that despite a soil deviating in its particle size distribution, e.g. in having too high a clay content, this does not mean that the site is poor for tree planting. Many plants thrive in a functioning clay soil. Instead, the plant material and construction of planting bed should be adapted to the conditions prevailing at the site.

Clay soils must be handled carefully since their good properties lie in the pores in the soil, i.e. in the air spaces between the clay aggregates. These must be preserved. Therefore clay soil is vulnerable to mechanical treatment and traffic in wet conditions. Addition of humus helps to maintain and improve the structure of clay soil. However, the humus must be mixed in superficially and carefully. When planting park trees in other soils it is good to dig large planting holes (Ø at least 3 m) and loosen the terrace and surrounding soil if they are found to be compacted. The soil only needs to be replaced if it is found to have poor zones such as old traffic areas or backfill soil with a low nutrient content and/or disturbed soil profile. When using existing soil as planting soil, it is often necessary to add nutrients to promote establishment and improve growth. The amount of nutrients applied is determined by analysis of a soil sample.

3.2 Trees in vegetation areas, disturbed soil profile

For new planting of trees in newly laid or reconstructed green areas in urban environments, e.g. park areas or continuous centre strips, there is seldom naturally formed soil available on the site for tree planting. In such situations it is necessary to create an entirely new growth medium profile that can function satisfactorily for trees. First an adequate planting bed profile must be created (minimum 800 mm) down to the terrace. In conditions where the terrace is compacted or where the material in the terrace deviates strongly from the planting soil, terrace drainage must be provided to remove excess water.

Large volumes of soil often have to be replaced when profiles with new planting soil are created. The profile can be up to 1000 mm thick. It is not very easy to manage large volumes of soil and there is a high risk of the soil being compacted or its structure being disturbed if it is not handled in the right way. When a thick layer (400-1000 mm) of new planting soil is used, there is always some degree of settling through the internal weight of the soil and decomposition of humus. Depressions gradually appear. The risk of settling by the actual tree is another problem, since it can cause the root junction of large trees to end up at the wrong level. When planting in newly applied planting soil with a deep profile, there is a tendency for the tree to sink into the loose soil. This gradually causes the trunk to end up too deep in the soil and oxygen deficiency can occur, compromising the success of establishment. This problem mainly applies in group- and pot-grown trees. The aim should be to fix the root junction of the tree at the level of the soil surface, see sample cases in section 6.2.

Example of disturbed soil profile where three different types of soil have been laid in layers on top of each other. One of the consequences of this is that water transport in the soil profile is greatly impaired. (Photo: Örjan Stål)
3.3 Trees in paved areas

The City of Stockholm has developed a template drawing that forms the basis for how street trees should be planted in the city, see section 6.3. Each tree must be given a volume of structural soil of at least 15 m³. The volume of aerated bearing layers and planting soil is in addition to this. Installation of the structural soil is described in section 6.3 and in a shortened version suitable for printed handouts under section 9.9.

Tree roots must be given the opportunity to grow unrestricted in at least two directions. In confined areas, e.g. between roadways, the minimum width of the planting bed should not be less than four metres for large forest trees, e.g. lime, maple and oak. For small trees, e.g. rowan, cherry and ornamental mountain ash, the width should never be less than two metres.

Where trees are planned for sections narrower than these specified widths, the rootable volume must be increased through structural soil or via piped culverts to adjoining grass or planting areas. This is a minimum requirement. More generous growth volumes give better growing conditions.

For a planting bed to function satisfactorily as regards water-holding and drainage capacity, the planting bed should have a depth of 0.8-1.0 m. The planting bed should also have a texture that gives good permeability in the soil. For new planting the terrace should be loosened down to 200 mm, preferably with a mechanical digger that lifts the soil/terrace material and lowers it back into place. Loosening with a pneumatic lance is another good method, particularly in clayey terraces. In compact terraces (for example soil with a high clay content 20 wt-% or more), drainage must be installed in the terrace to ensure that excess water is carried away from the planting bed.

The mineral soil and planting soil must be applied in a single operation and should not be compacted in layers. The mineral soil should have the same particle size distribution as the planting soil, with the only difference that the mineral soil has a humus content of max. 2 wt-%. The soil masses applied must not be trafficked. If the soil is inadvertently compacted, it should be loosened with the help of a front-loader that breaks up the compacted layer through lifting and releasing the soil. In permeable conditions (sand- and gravel-dominated soil), planting soil can be used for the entire profile.

3.4 Trees above basement

For trees planted in confined areas, e.g. above a basement, that only allow a low construction height (<800 mm), it can be difficult to provide trees with adequate growing conditions. Planting beds with low profile height require a relatively large fraction of pores so that excess water can be drained away. In compacted soils with a high clay content, there is a risk of oxygen deficiency developing in the planting bed. This means that only gravel- and sand-dominated soils can be used with low construction heights. In these coarse-textured soils the water- and nutrient-holding capacity is relatively limited, which means that such plant beds
require continual watering and fertilisation if they are to function as a growth substrate. To achieve a high pore volume while still keeping the water-holding capacity relatively high, it is recommended that the planting bed be constructed from a pumice-based soil (see section 2.5, Planting soil C). The properties of the pumice mean that the soil can supply the plants with plant-available water while remaining free-draining, with good oxygen turnover in the planting bed. It is important to point out that the pumice cannot be replaced by e.g. lava or leca material if the aim is for the planting soil to retain sufficient amounts of plant-available water.

The lowest recommended construction height for medium-sized trees above a basement is >600 mm, for large trees > 800 mm and for small bushes 400 mm.

3.5 Inspecting plant material/checking deliveries
Inspection of the plant material immediately on delivery to the construction site is an essential stage in successful establishment of trees. All deliveries should be checked by an authorised inspector and the quality of the plants must comply with the document ‘Quality Specifications for Nursery Plants’ produced by GRO Nursery Plant Division, 3rd ed., 2003. Plant quality can vary between different nurseries despite the same quality specifications being listed on the delivery note. Deliveries should be checked immediately on delivery of the plants from the nursery to the planting site. Trees are sometimes damaged during transport, e.g. in loading and unloading, so it is vital for the inspector to be present when the plants are unloaded so that any damage occurring to trunk and crown during transport can be detected at once. The inspector photodocuments the plants and any damage, and carries out checks. In addition to mechanical damage, the inspector records signs of disease, general plant quality, correctness of the species/variety delivered compared with the order, and numbers. Plants that do not comply with the order should not be accepted.

General demands on quality and plant handling: Plants with a root ball or pot-grown plants are used. Large trees should be handled so that no damage occurs to trunk and crown. Plants should preferably be planted immediately on delivery. The root ball should be kept moist until planting. If the tree cannot be planted at once, it should be buried in soil. It is important to note the weather conditions, since sun and wind quickly dry out plants.

Planting conditions for street trees in Stockholm, along the Klaraberg viaduct. A bunker-like concrete structure filled with planting soil type C comprises the growth volume. Functioning gas exchange is ensured via the orange ventilation pipes. The concrete ring in the centre ensures that the tree does not subside and sink into the soil volume. The root junction of the tree is thus fixed. (Photo: Björn Embrén)
4 PLANT BED RENOVATION

Plant bed renovation aims to create better growing conditions for urban trees with a poor growing site. This method is based on reconditioning the growing site closest to the tree without removing the tree. The method was developed in Germany with the aim of reversing a deteriorating life process and saving trees with poor vitality. Improving the growing site results in trees becoming healthier, greener and developing a fuller crown volume. This contributes to extending the lifetime of the trees.

To provide trees in paved environments with better growing conditions, as much as possible of the bed material plus any compacted carrying and reinforcing layers close to the tree must be replaced with a plant bed volume appropriate for the tree. For trees in paved areas this often involves constructing a root-friendly bearing layer (structural soil) as the rootable volume. The surface paving should be designed so that stormwater can be infiltrated into the structural soil and the plant bed (see section 2.4).

The best way of adding organic material to the soil surface is to make open areas around the tree into planting areas. In situations with a risk of wear from cycle and pedestrian traffic, gravel is an option for the surface cover.

The objective with plant bed renovation is to achieve more vital trees through:

• Improving the conditions for gas exchange in the soil
• Increasing the volume of plant-accessible soil for every tree
• Creating good permeability in the soil
• Increasing the infiltration of rainwater into the soil
• Creating possibilities for fertilisation and/or addition of organic material

In the sample cases in section 7, the procedure involved in plant bed renovation is described.

4.1 Assessment prior to plant bed renovation

Since plant bed renovation costs a lot of money, prior investigation of site conditions is justified. The existing design with the current tree placings is perhaps not optimal for future needs. The following should be investigated before plant bed renovation begins:


**Tree status**

A condition assessment must be carried out on any trees present, through visual inspection of vitality and damage to trunk, etc. If there are uncertainties as regards damage, cracks or tree vitality, the trees should be examined by an authorised expert, e.g. a consultant arborist.

**Space in the soil**

The scope that exists in the soil to improve and/or expand the rooting environment should be examined. A check should be carried out for pipelines, underground structures, physical barriers such as roads, etc. Land ownership issues should also be clarified.

**Aesthetics and heritage listing**

Is it possible to redesign the site? Are there any restrictions regarding operations and changes at the actual site?

**Tree placement**

Is saving the trees justifiable? Aspects such as traffic safety, shading, upkeep, etc. should be considered in such an assessment. Plant bed renovation can transform an underdeveloped tree into a fully grown tree over time so factors to be considered are whether that will leave space for the crown or give rise to expensive upkeep measures.

**Test digging**

Test digging is essential if plant bed renovation is to give good results. Test digging provides information important for planning the renovation procedure.

4.2 Preparation work, test digging

One or more test holes should be dug where plant bed renovation is to be carried out. Investigate where tree roots are located and their thickness. Study the soil profile, the composition of the soil, the thickness of reinforcing layers and any compacted zones. Test digging is not without risk for trees, so it must be carried out with maximum care in the form of manual digging with the help of a digging tool. Test holes must be documented with pictures.

Important questions answered by test digging:

- The thickness of the upper profile of the paved area (bearing and reinforcing layers).
- The depth at which a dense root mat begins.
- Where and how major roots are growing (under certain extreme circumstances in urban situations, trees can develop thick roots called pipelines that provide the majority of the tree’s supply of water and nutrients, see picture on page 28).
- Nutrient status, humus content and particle size distribution in existing planting soil.
- Presence of compacted zones in the soil profile.

Illustration of the space available in the soil in an urban situation. The plant-available volume for tree roots is often very restricted due to underground installations. (Illustration: Per Magnus, Traffic Division, Stockholm)
The number and location of test holes dug must be decided for each specific project. Site conditions vary. For trees in park environments, anything from 3-10 small hand-dug holes may be needed to determine the soil situation and identify where roots are growing.

If the tree is growing in a paved environment, larger holes (approx. 1.0 m²) should be dug in 1-2 selected places. Tree size is of critical importance for the siting of the test holes. With small trees (trunk circumference < 50 cm), test holes can often be dug only a few metres from the trunk. With older and larger trees, attention should be paid to large, superficial roots and how they are growing. In such cases the test pit can seldom be placed closer than 2-3 m from the tree trunk. An important aspect when digging test holes is that trees with poor growing conditions can develop a few coarse roots that supply the tree (see picture on p. 28).

**Checklist for test digging:**

- Tree age. How old is the tree and how much has it grown in recent years?
- Tree species. Different species have different degrees of susceptibility to exposure of large roots. The most sensitive are beech, birch, horse chestnut and maple.
- Nutrient status, humus content and particle size distribution in the soil.
- Soil texture/structure affects choice of digging method. For example, in clay-dominated soils it may be difficult to carry out vacuum excavation. Large compacted areas also place specific demands on digging operations (see also below under Comments).
- Soil volume and growing site.

**Comments:** Built-up soil can often be dug out using a mechanical digger since there are often few roots.

Built-up soil with different layers, e.g. bearing layer/soil or compacted soil layers, often require a larger volume of excavation.

Stony, gravel and sandy soils (single-grain structure) are easy to dig. They can in principle be dug at any time of the year. Soils dominated by silt and clay (fine particles) are much more difficult to dig and it can be very difficult to dig close to trees in dry or wet conditions.

Large superficial roots can cause problems in making good after digging work. If large superficial roots are present, options such as general raising of the soil level or root pruning should be considered.

If digging shows the existing root system to be at depths of 600 mm or greater, this places additional demands on the new soil profile as regards drainage, aeration and content of organic material.

The presence of pipes can hamper, or in some cases completely prevent, digging and backfilling work.
4.3 Plant handling - pruning and protection of tree roots

Too often, trees are damaged unnecessarily due to careless machine work. Pruning of roots close to the tree is often unavoidable during digging operations. This also applies for plant bed renovation. There are certain criteria for root pruning that must be respected in order to minimise damage to trees. The following are simple criteria for pruning of tree roots:

Pruning of roots with diameter > 30 mm at a distance of less than three metres from the tree trunk should be avoided if at all possible. Larger roots with diameter > 50 mm can be pruned in individual cases if this is done more than three metres from the trunk. If pruning of large roots is unavoidable, good growing conditions are necessary to stimulate the formation of new roots. All pruning of tree roots must be done in consultation with the client.

It is just as important to avoid damage to large roots as it is to avoid cutting them off. Grazes to bark and roots are a common form of damage that can lead to rots in the tree in the future.

Small roots are more sensitive to drying out and frost damage than large roots. However, small roots cope better with pruning since they produce new fine roots more easily.
Correctly pruned coarse roots.

Root Ø > 50 mm. Incorrectly hacked off. Must be pruned further along into the soil where there are no cracks. Should be cut off with saw or clippers.

Correctly pruned root system. (Photos: Örjan Stål)
Protection of roots

Roots that are exposed should always be kept damp and watered. For long periods, more than an hour with freely exposed tree roots, the roots must be covered to retain moisture with a tarpaulin, geotextile or sacking etc. This also applies when work is being carried out in strong sunlight, wind or below zero temperatures where the roots are exposed for than 15 min. Watering should be carried out so that the water does not run off the surface but infiltrates down between the roots or into the terrace base.

Exposed roots protected with coconut fibre/jute matting. (Photo: Örjan Stål)

Root that had been pruned correctly in previous digging work. The wound has begun to heal over. (Photo: Örjan Stål)

Roots exposed by vacuum excavation being watered as protection against drought. (Photo: Björn Embrén)
Root wrapping consisting of coconut fibre matting held in place by tree supports and wet soil. When backfilling work cannot be done at once, root wrapping protects tree roots from drying out.

Geotextile placed on top of coarse tree roots as protection against sharp stones before backfilling. (Photos: Örjan Stål)
4.4 Excavation methods
In addition to manual digging, there are two mechanical excavation methods that can be used in plant bed renovation: air- and water-based methods and conventional excavation with a mechanical digger. Air- and water-based techniques, e.g. vacuum or hose excavation, are root-friendly methods that cause little damage to tree roots. This technique is used in situations close to trees where shallow and/or coarse roots occur. Conventional mechanical digging is more cost-effective and is used when no or few small tree roots occur.

When coarse roots (root Ø > 30 mm) or a dense root mat are present, excavation methods that cause little damage to the root system must be used. For removal of small quantities of material, manual digging is possible. For larger volumes the soil can be sucked out with a vacuum excavator in combination with the soil being loosened with the help of compressed air. When the root system is lying at shallow depth, compressed air or a high pressure water jet can be used to remove the bed material. In general, the surface layer is removed if it consists of bearing layers, compacted soil or depleted soil. Parts of the existing root system must be uncovered so that it can come into contact with the new nutrient-rich and well-aerated growth substrate. Digging should cease when a large amount of fine roots has been exposed. This normally occurs at an excavation depth of 500-600 mm but in some cases it is necessary to dig to over a metre before roots are encountered. Regardless of excavation method, damaged roots must be pruned correctly. Read more about the vacuum technique in the sample case in section 7.2.

4.5 Precautions before backfilling
Precautions to be taken before backfilling consist of the procedures: loosening, pruning of roots and protection of roots against drying and freezing.

Loosening
Loosening of the terrace is an essential procedure if renovation is to succeed. This procedure is often overlooked. Compressed air is an effective and non-damaging method to use in loosening the terrace base and in and under the exposed root system. In compressed air loosening, a metal lance fitted with a pistol grip is inserted into the soil layer to a depth of 800-1000 mm at c/c intervals of 800-1000 mm. Air is blown through the lance and causes an explosive effect in the soil. To achieve sufficient air pressure, a compressor with a capacity of 8-10 m3 air/min. and a pressure of 7-8 bar is required. Where the terrace is densely compacted and where there are no large roots, loosening can be carried out mechanically with a hand implement which is inserted into the soil and breaks up the compaction.
Trees in confined situations can develop coarse roots called pipelines, which supply the tree with the majority of its uptake of nutrients and water. It is important to save these roots in plant bed renovation. With the vacuum technique these roots can be exposed and mapped without damaging the root system. In traditional mechanical excavation there is a patent risk of these roots being damaged. (Photos: Örjan Stål)
5 UPKEEP, MONITORING AND COMPENSATION MODEL

5.1 Monitoring programme during construction

The monitoring programme aims to clarify and quality assure the construction process in new planting and plant bed renovation, i.e. to check how the planting beds are constructed, monitor the planting procedure and oversee the upkeep. The monitoring programme is a safeguard for both client and contractor, since it provides clear documentation of the entire construction process. For a planting bed to be approved by the official inspector, clear documentation of the construction process must be provided by the contractor. Soil analyses with a particle size distribution curve and nutrient analysis for all planting soils and mineral soil must be submitted to the client. This applies to existing and artificial soil. Important stages during the construction process (so-called key stages) must be reported continuously to the client during construction. These key stages are photodocumented and submitted as digital images to the client. The continuous information to the client gives the client time to react to errors and correct these before the planting beds are completed. The key stages are listed below as bullet points.

Key stages in new planting, trees in vegetation areas (see sections 6.1 and 6.2)

- Production and review of soil sample analyses
- Digging of plant beds
- Loosening of terrace
- Improvement of existing planting soil with fertiliser and possibly compost
- Laying of mineral soil and planting soil type A-C, see section 2.5
- Planting and watering

Continuous monitoring during construction, planting and guarantee upkeep is central in achieving as effective establishment as possible. (Photo: Örjan Stål)
Key stages in new planting, trees in paved areas (see section 6.3)

- Production and review of soil sample analyses
- Loosening of terrace
- Installation of structural skeleton
- Watering-in of planting soil type D into structural soil, see section 2.5
- Laying of aerated bearing layer
- Laying of geotextile
- Laying of mineral soil and planting soil type A-C, see section 2.5
- Planting and watering
- Tree support and tying-in.

Key stages in plant bed renovation (see section 7)

- Production and review of soil sample analyses
- Uncovering of roots
- Protection of exposed root system
- Loosening of terrace
- Laying of structural skeleton
- Fertilisation with slow-release fertiliser between laying of structural layers
- Watering-in of planting soil type D into structural soil, see section 2.5
- Laying of aerated bearing layer
- Laying of geotextile
- Laying of mineral soil type A-C, see section 2.5
- Laying of planting soil type A-C, see section 2.5

Watering of trees in vegetation areas can be facilitated by creating a ridge of soil to keep the water at the tree and planting hole. Mulch in the form of bark, compost and fertiliser stimulates biological life in the soil and prevents evaporation. This method is preferable to installing drainage hoses from both an establishment and environmental viewpoint.

Fertilising with a slow-release compound on structural soil. Note that the structural skeleton is visible after correct watering-in of planting soil. (Photos: Örjan Stål)
5.2 Assessment of compensation for damage to trees (see Appendix 9.7)
Trees in the urban environment are often exposed to damage, both to aboveground plant parts such as trunk and crown and to the root system. For this reason, a compensation process for damage to trees is included in construction contracts. However, it is difficult to set the amount of compensation for damage where the tree does not die at the time of damage. The assessment of minor damage is particularly difficult.

An assessment protocol has therefore been drawn up so that compensation can be set for damage to trees. The protocol gives a specific amount of compensation for every unique case of damage. The compensation amounts are based on the penalties for trees specified in the original contract (AF-section). These penalties are then related via the assessment protocol to the observed damage to crown, trunk, and root system. The damage observed is weighed by percentage into different categories of damage.

During inspection for damage assessment, all types of damage to branches, trunk, or root are noted. Via a predetermined percentage factor, the amount of compensation is calculated for every individual category of damage. The value of all damage noted is then added up to give the total amount of compensation to be paid. However, the total amount of compensation for an individual tree may not exceed the penalty specified in the original contract.

The protocol can be varied depending on specific conditions such as tree species, size, and shape. However, it is important to clarify the assessment criteria that apply to the job when the compensation procedure is decided. This compensation model can be used for all trees owned and managed by the City of Stockholm.

5.3 Description of work involved in guarantee upkeep
The requirements as regards upkeep of newly planted trees are presented below (excerpt from City of Stockholm’s description of work involved in guarantee upkeep).

General for urban trees
Within a 75 cm radius measured from the trunk, the surface should not be grass-clad. The soil must be free from weeds. Where the client approves a bark mulch, 100 mm of mulch is laid around trees in lawn areas at the time of guarantee inspection.
Watering

The amount of water applied must be at least 140 litres per tree every other week during the period 15 April to 31 August. Water must always be available to the trees. Watering must be carried out so that the water is evenly distributed into the tree root ball/planting bed (use of a watering bag is appropriate here). The planting bed/root ball must never dry out and must be obviously moist. Watering must be carried out in such a way that problems are avoided. All watering/fertilisation inputs must be documented in a diary and submitted to the client within a week of completion of work.

Regular measurement of soil moisture at the growing site is used to check that the trees have been given a satisfactory growing environment with uniform moisture.

Fertilisation

Fertiliser is applied on every watering occasion throughout the entire growing season, starting in April, with a weak nutrient solution of 1-2 parts per thousand. The fertiliser used must be water-soluble and have an approximate composition of 51% N, 10% P and 43% K. The fertiliser must also contain micronutrients. One of the products with that particular composition is Walco, which is produced by Cederroth. Similar fertilisers are also available from other manufacturers such as Yara, LMI, etc. For park trees a 100 mm thick layer of well-rotted cow manure should be applied in spring on the entire surface area of the planting hole (diameter = 150 cm) where the client considers this appropriate. There are other important factors that may prevent this being done, e.g. aesthetic, underplanting of perennials, etc.

Tree care

All pruning must be carried out professionally by trained staff with documented knowledge of plant care. Pruning must be performed in accordance with the CODIT model. Dead and damaged branches and root and trunk shoots must be removed. All pruning must be carried out in consultation with the client.

Expiry of guarantee period

At the end of the guarantee period, the installation should have a well-established appearance. Trees should show good establishment and growth. Trees should have a general shoot growth rate of at least 200 mm per year. During the growing season, leaf colour can also be assessed.

Watering is a central part of the establishment process. Here newly planted trees are being watered with a watering bag, where water percolates slowly through the bottom of the bag. This watering bag holds 70 litres of water. (Photo: Björn Embrén)
SAMPLE CASES WITH DRAWINGS
New planting
6 SAMPLE CASES WITH DRAWINGS, NEW PLANTING

6.1 Trees in vegetation areas

Planting bed for trees in vegetation areas – procedure

• Existing soil can be used and only the turf layer is removed (approx. 100 mm deep) in a radius of approx. 2 m per tree.

• A generous planting hole with a radius of at least 1.5 m is dug. New planting soil type A can be used in the planting hole if the existing soil is not considered adequate.

• In the area from which the turf has been removed, the top soil layer must be improved with compost and manure. In terms of soil nutrient status, the upper 400-500 mm of existing planting soil must meet the general requirements specified by AMA Installation 07 Table RA DCL/1. On clay soils, compost and manure are worked in with a hand implement or similar. A rotavator must NOT be used for this purpose since it destroys important clay aggregates.

• The planting bed must be raised, with a height difference compared with the existing soil of around 100 mm. The surface including the area from which turf was removed must be covered with 150 mm mulch (park compost) and fertilised with 10 kg/100m² of granulated chicken manure, which is worked in. A tidy appearance must be created by covering the surface with 50 mm non-conifer bark chippings.

• In clayey conditions the planting bed must be raised at least 300 mm above the height of the existing soil. In situations with a terrace, care must be taken to ensure that the existing soil is not compacted. Planting work must not be carried out in saturated clay soil.

• Trees are watered after planting so that the entire profile is saturated.

• Water bags are used for continuous watering to ensure successful establishment.

Trees planted in park area. Despite their location in the immediate vicinity of the street, these trees have good soil conditions. (Photo: Örjan Stål)
SAMPLE CASES WITH DRAWINGS, NEW PLANTING

SECTION

NEW PLANTING - TREE IN VEGETATION AREA, NATURALISTIC SOIL PROFILE
Principle section
SCALE 1:20 (A2), 1:40 (A4)

NEW PLANTING - TREE IN VEGETATION AREA, MULCH FOR PARK TREE
Principle section
SCALE 1:10 (A2), 1:20 (A4)

SECTION

NEW PLANTING - TREE IN VEGETATION AREA, CLAYEY SOIL
Principle section
SCALE 1:20 (A2), 1:40 (A4)

NOTES
- Tree hole #3-4 m.
- Situation with clay content >20%

NOTES
- All data in mm unless otherwise specified.
### 6.2 Trees in vegetation areas (disturbed soil environment)

**Planting bed for trees in vegetation areas (disturbed soil environment) – procedure**

- **Existing soil within an area of at least 10 m² must be dug out for each newly planted tree (size of this area can be adjusted for tree size) down to a depth of 800-1000 mm.**

- **Crushed rock in the size fraction 32-63 mm must be laid in the centre of the planting bed (under the root ball) so that the tree is prevented from subsiding into the soil profile after planting.** Planting soil is scattered over the crushed rock layer and brushed down between the stones. All spaces do not need to be completely filled and the crushed rock should not be compressed down.

- **Drainage is installed in the terrace and connected up to the existing drainage system so that excess water can be transported away.**

- **New planting soil type A should be used in the excavated area on clay soil and type B or type D in other situations.** The soil must be homogeneous throughout the entire profile, i.e. there should not be any major differences in texture in the soil profile. NB! Low humus content in the entire profile as below.

- **The planting bed must be raised by around 200 mm above the existing soil.** The surface may be covered with a 150 mm mulch (park compost) and fertilised with 10 kg/100m² granulated chicken manure, which is worked in. A tidy appearance must be created by covering the surface with 50 mm non-conifer bark chippings. The mulch helps e.g. to create better biological life in the soil. In areas with high populations of voles, the mulch method may be unsuitable since voles thrive under the mulch layer.

- **The humus content in the new soil should be low, 2-4 wt-%.** In situations with a clay terrace particular care must be taken to ensure that the humus content in the soil profile is low.

- **Existing soil must be pneumatically loosened within a radius of at least 2 metres around every newly planted tree.**

- **Trees are watered after planting so that the entire profile is saturated.**
NEW PLANTING - TREE IN VEGETATION AREA, DISTURBED SOIL PROFILE

Principle section
SCALE 100 (420, 760 (144))

NOTES:
All data in mm unless otherwise stated

Drainage #188
is placed in the longitudinal edge of the planting area. Terrace lifted 3%.
6.3 Trees in paved areas

Structural soil – procedure

Structural soil is constructed from a root-friendly volume of crushed rock with stone fraction 100-150 mm. The volume of crushed rock often has a total thickness of 600 mm or more. The crushed rock is laid in 250-300 mm layers that are compressed by at least four passes with a vibroplate.

Planting soil type D (see Appendix 9.4) is laid on the crushed rock and is flushed down between the layers of crushed rock at high pressure. In order to infiltrate the right amount of soil into the crushed rock, each layer of planting soil must not exceed 20 mm thickness. The planting soil is applied in several layers so that the entire volume of crushed rock is saturated. There should be no surplus soil lying around after application. The crushed rock must be visible in a soil-filled boundary layer (see picture on p. 40 fertilisation of structural soil).

Estimated amount of planting soil needed for 1 m³ crushed rock = 0.25 m³ planting soil. In situations where the existing soil in the terrace has a clay content >10 wt-%, the clay content in the planting soil can be lower. However, the clay content in the planting soil should never be less than 4 wt-%. The planting soil must meet the nutrient requirements specified in AMA Installation 07 Table RA DCL /1, see section 2.

The structural soil is fertilised with slow-release fertiliser with eight months leaching time. The dose is 100 gr/m², which in practice is equivalent to approx. 1 handful/m². Fertilisation is carried out during construction of the structural soil and the fertiliser is laid in layers with the planting soil.

To level off the structural skeleton, a 200 mm aerated bearing layer of 32-63 mm crushed rock is laid on top. The material is compressed with a 400 kg soil vibrator. Geotextile is laid on top of the aerated bearing layer, followed by a suitable surface layer for the specific project.

Problems with large tree root balls in specialist earth equipment

There is sometimes a need for specialist earth equipment for the planting hole. Planting holes are often designed with restricted dimensions in cities. Problems can arise if the designer has not correlated the minimum dimensions of the tree hole to plant quality. Large trees, which are often suggested for cities, have a large root ball. If the root ball does not fit in the hole at planting, a decision is often made to prune the root ball, which has devastating consequences for tree establishment. In such situations the contractor/site foreman must use foresight and correct the error earlier in the construction process. The drawings should be adjusted or new trees of the right size to fit the planned dimensions should be ordered. Alternatively, the soil on the root ball should be washed off so that the fine root system can be retained. If trees without a root ball are planted, the contractor must compensate for the lower stability by providing good support for the trees. The best option is of course to have the plans drawn correctly in the first place.
Precautions around existing sewage pipes
Root intrusion into existing sewage pipes is a common phenomenon. In situations where the planting bed/structural soil is situated in direct proximity to existing sewage pipes, the pipes can be protected with thermally treated geotextile, 125 gr/m².

Procedure for constructing structural soil (see also short printable version in section 9.9)
1. The height of planting boxes and air and infiltration inlets is adjusted with crushed rock. Do NOT use sand or gravel.
2. The crushed rock (100-150 mm crushed rock) is laid out in 250-300 mm layers and compressed by at least four passes. It is very important that the crushed rock is packed down before the soil is applied so that the soil is not compacted between the rock.
3. The soil is applied in layers of 20 mm thickness and watered into the structural volume (crushed rock). Use small amounts of water and high pressure.
4. More planting soil type D is added and watered in until the crushed rock is saturated. Around 25-30% of planting soil can be accommodated in the structural soil volume (10 m³ crushed rock = 2.5-3 m³ soil).
5. The crushed rock in the filled layer should still be visible when the next layer of crushed rock is applied. This is to avoid compaction of the planting soil.
6. Slow-release fertiliser 100 gr/m² (= one handful/m²) is applied on each structural layer.
7. When the full height of the structural soil profile has been reached, an aerated bearing layer of 32-63 mm is laid on top, packed down well and covered with geotextile.
8. The surface structure is completed with layers of gravel and surface covering.
9. The planting soil is filled into the planting hole and the tree can finally be planted.
Continuation from previous page. Planting soil type D being hosed in, the structural soil being fertilised, the aerated bearing layer being laid, material-separating geotextile and gravel being laid, inlet covers for water channels being set in place and tree grid and paving being installed.
NEW PLANTING - TREE IN PAVED AREA WITH SOIL COVER VEGETATION

Principle section

Scale 1:20 (A2), 1:40 (A4)

NOTES

All data is mm unless otherwise specified.

Notes:

Soil equipment such as gratings, trunk guards, tree support are specifically adapted to the project. Fine crushed rock must not be used in structural soil profile for adjusting air inlet or concrete bunker.
NEW PLANTING - TREE IN PAVED AREA WITH SURFACE GRID

Principle section

Scale 1:100 (A2), 1:50 (A4)

Notes:
- Soil equipment such as grating, front guards, tree support are specifically adapted to the project.
- Fine crushed rock must not be used in structural soil profile for adjusting air inlet or concrete smaller.
- In specially constructed tree holes with narrow dimensions, fine crushed rock must be avoided with increasing front circumference clamp diameter increases.
- Use 0/8 regulations for nursery planting.
- Grine, Plantahandel, Strupplingen, August 2003.

In compact and or clayey terraces, drains surrounded by crushed rock are laid. Access to pesticides and drain or crushed rock ditch for water removal.

200 mm crushed rock 55-65 mm

600 mm crushed rock 100-150 mm

Aerated bearing layer

200 mm crushed rock 35-55 mm

Inlet type TL 3333 Charcoal or equal placed on structural soil surface for air and water supply.

1 per tree

600 mm crushed rock 100-150 mm structural soil with planting soil type D

Soil equipment such as grating, front guard, tree support are specifically adapted to the project.

Fine crushed rock must not be used in structural soil profile for adjusting air inlet or concrete smaller.

In specially constructed tree holes with narrow dimensions, fine crushed rock must be avoided with increasing front circumference clamp diameter increases.

Use 0/8 regulations for nursery planting.

Grine, Plantahandel, Strupplingen, August 2003.
NEW PLANTING - TREE ON BASEMENT, PAVED AREA

Principle section

Scale: 1:20 (1:25, 1:50, 1:100)

NOTES

- All data in mm unless otherwise specified

Tree

- Tree diameter

Soil type and volume per tree

- Soil moisture and planting

Tree support

- Tree support specific to the project

Diagram:

- Inlet cover as described
- Access pipe for moisture measurements
- Depth 400mm
- Curved surface material 100mm, crushed rock 4-6mm
- Surface grid 300x300mm
- Concrete lid
- Gravel/tile 3rd
- Reinforced mesh
- Waterproof layer on pavement
- Protective concrete
- Soaker hose
- Light weight soil, planting soil type C
- Minimum 400mm
- Pumice stone
- Inlet type TLV 3000 Elroy
- Drainage layer 70mm
- Support wall at concrete
- Sump outlet
- Holes in concrete lid
- Adjacent to an inlet
- Stormwater cover, divided
- Version available for laying
- Gutter

Material:

- Separating layer, coconut matting HKS 700g/m²

Other:

- Diameter for supporting legs designed specifically for the project.
LOCAL DISPOSAL OF STORM WATER - TREE IN PAVED AREA WITH STRUCTURAL SOIL

Principle section

Scale 1:20 (A2), 1:40 (A4)

NOTES

- All data in mm unless otherwise specified.
- Soil equipment such as gratings, tree guards, tree support are specifically adapted to the project. Firm crushed rock must not be used in structural soil profiles for adjusting air inlet or concrete bumper.

LOCAL DISPOSAL OF STORM WATER

TREE IN PAVED AREA WITH STRUCTURAL SOIL

SECTION

Scale 1:1000/1:2000

THV0026
INSTRUCTIONS
Trees < 14 m can have a simpler tie with thinner posts or only one post.
All posts must be untreated.

REFERENCE
See also instruction 1402 in Technick handboek 2007 dt. + rijtuig sleeping.

NOTE
All data in mm.

SECTION
SCALE 1:20

PLAN
SCALE 1:20

TYING-IN OF STANDARD TREES
SCALE 1:20

NOTES
All data in mm unless otherwise specified.
6.4 Vegetation areas for bushes, perennials and grass

Vegetation area for bushes/perennials
Principle section
SCALE 1:20 (A2), 1:40 (A4)

Grass
Planting soil type A, B or C
Leveling 200 mm

Vegetation area for grasses, naturalistic soil profile
Principle section
SCALE 1:20 (A2), 1:40 (A4)

NOTES
- Planting soil must be type A-D as in appendix 9.1-9.4.
- Planting soil clay content is adjusted to terrace composition
- in table DC/2 Annex 97.
- Terrace 1A-1B planting soil type 2.
- Terrace 1B planting soil type D.
- Terrace 1C-1D planting soil type A.

Vegetation area for grasses, disturbed soil profile
Principle section
SCALE 1:20 (A2), 1:40 (A4)

NOTES
- Planting soil must be type A-D as in appendix 9.1-9.4.
- Planting soil clay content is adjusted to terrace composition
- in table DC/2 Annex 97.
- Terrace 1A-1B planting soil type 2.
- Terrace 1B planting soil type D.
- Terrace 1C-1D planting soil type A.
- When laying turf under existing trees,
  note existing tree roots. See section 4.3.
- When laying turf the section is completed with
  30 mm dressing of sand on top of planting soil.

Vegetation area for bushes, perennials on basement
Principle section
SCALE 1:20 (A2), 1:40 (A4)

Grass
Planting soil type C
Leveling 200 mm

NOTE
When laying turf the section is complemented with
30 mm dressing of sand over planting soil.

Vegetation area for grasses on basement
Principle section
SCALE 1:20 (A2), 1:40 (A4)

NOTES
All dimensions in mm unless otherwise stated.
7 SAMPLE CASES WITH DRAWINGS
Plant bed renovation
7 SAMPLE CASES WITH DRAWINGS, PLANT BED RENOVATION

The procedure for plant bed renovation differs from case to case. This section contains sample cases for some different situations. These samples show the situation before and after work has been carried out.

7.1 Small trees with poor growth

Small to medium-sized street trees are represented here by young trees up to 30 years old planted in concrete or wooden bunkers. The trees are surrounded by paved surfaces with a tree grid or small open gravel/earth area around the tree trunk. The procedure is similar to that for new planting of street trees.

Procedure

- The surface layer around the trees is removed. This includes gravel (plus any geotextile), tree grid, surface covering and gravel. For rows of trees, the surface covering between the trees is removed to a min. width of 1.7 m. Digging starts at the outside edge and continues in towards the respective tree. If few or no roots are discovered the area is dug out to a max. depth of 1 m. The area around the planting hole can be dug out with a mechanical digger assisted by manual digging.

- When there is 1 m left to the edge of the existing planting hole, the depth of digging must be adapted to the depth of the planting bunker. This means that the depth of the trench closest to the planting hole is often at a max of 600 mm.

- For trees that have large roots (diameter > 3 cm) outside the edge of the planting hole, the area can be dug out to the level where a dense root mat is encountered, although to a max depth of 600 mm. Digging in the presence of large roots should be carried out using a root-friendly method.

- Exposed roots are pruned and protected as specified in section 4.3.

- Structural soil and aerated bearing layer are laid in the trench as described in section 6.3. Any roots in the aerated bearing layer are protected with 4-8 mm crushed rock and a geotextile covering.

- Pavements/surfaces are replaced as described in the plans for the specific project.

- Upkeep is monitored as in section 5.
SECTION EXCAVATION

SCALE 1:20 (A3), 1:40 (A4)

Inlet type TLV 3233 Clayoo or equivalent placed on structural layer for air and water supply 1 per tree

Stemwater cover

Spacer ring of concrete for height adjustment

Surface/superstructure

Airhole placed at level of aerated bearing layer

Excavation depth 1 m

Existing concrete wood frame

Existing tree

70 mm surface material crushed rock 4/8 mm

Existing tree ends

Geotechnical classification G

Concreteination

Structural soil with planting soil type D

profile depth 400 mm minus content 5-8 *1% in entire profile
profile depth 400 mm minus content 4-6 *4% in entire profile
Fertilizer, 6 mm, laying time 100g/m², placed on terrace
and for each layer of structural soil

Loosening of terrace 200 mm

Laying roots protected with backfill of crushed rock 4/8 mm

Air inlet adjusted to 2-4 mm
or coarse crushed rock

SECTION MAKING GOOD

SCALE 1:20 (A3), 1:40 (A4)

NOTE
All dimensions in mm unless otherwise stated
7.2 Large street trees with shallow root system

This section describes situations with large, older trees (trunk circumference > 100 cm) with a shallow root system in a paved surface. Root-friendly excavation methods, e.g. vacuum excavation, must be used here. See also under Excavation methods, section 4.4.

**Vacuum excavation**

Vacuum excavation is a technique that is best carried out with a vacuum pump that has a suction capacity of at least 0.8 bar and an air volume capacity of 8 600 m³/h or more.

The procedure is as follows: Pressurised air is forced into the soil through a metal lance that is equipped with a pistol grip. A strong stream of air creates an explosive effect in the soil. Air loosening makes the spoil more porous and thus easier to suck up with the nozzle. The underlying terrace can also be loosened with metal lance. A diesel-powered compressor with a capacity of 8-10 m³ air/min and a pressure of between 7-8 bar is needed to create the correct air pressure. Note that in autumn, vacuum extraction cannot be carried out at -5°C or below. At minus temperatures the soil material must not be too wet since it clogs the suction hose (does not apply for gravel). In general, the best time for vacuum excavation is when the soil is at field capacity, which often occurs in early spring or during the autumn.

When the excavation spoil is too hard and dry it is difficult to carry out vacuum excavation. This applies particularly to soils with a high clay content. The soil then has to be watered so that it softens up. For suction work to be possible on clay soils, the soil must have a water content corresponding to field capacity. This level can be reached if watering is carried out for at least two days at a rate of 20-30 mm water/m². If the soil is still either too dry or too wet at the time of digging, the soil can be sucked out if it is water-saturated. In these conditions the material sucked out has the consistency of a slurry rather than soil. This means that it is usually not possible to dump the extracted spoil locally on the site and the suction tanker must transport it to a suitable place, which increases the time requirement and thus the cost of the work.

In poor soil conditions, the roots of street trees grow where there is air and moisture, i.e. into the sand directly beneath the pavement. These roots increase in size over time, forcing the pavement upwards and cracking the surface layer.

Exposed root system of a Norway maple in Stockholm. A park tree with a well-developed and densely branched root system near the soil surface. (Photos: Örjan Ståhl)
Procedure

- Surface layer of asphalt or concrete slabs around the trees is removed.
- Bedding sand and the bearing layer must be removed by root-friendly excavation methods since there are often tree roots in these layers. Excavation should start from the tree trunk and work outwards.
- To avoid excessive damage to large roots when laying a new structural soil, the open area around the tree should be expanded or the surface around the tree raised by 50-100 mm. This must be decided by the client on each specific occasion. Shallow small roots are pruned. Larger roots that are overlain with a new bearing layer must be protected against sharp stones with geotextile (utility class 3). Tree roots that end up at the same level as the aerated layer are protected with 4-8 mm gravel and a geotextile covering. Pruning of tree roots is performed as described in section 4.3.
- Structural soil and aerated bearing layer are laid as described in section 6.3.
- Pavements/surfaces are replaced as described in the plans for the specific project.
Air and stormwater inlets of type Clarova, here with cast iron covers and a compacted bearing layer. The stretch contains new planting holes and renovated plant beds for existing street trees.

Restoration of new surface layer with concrete slabs. The frame for the tree grid is laid on a concrete bunker or concrete sills. The finished construction has a rootable growth volume of 15 m³ per tree. The orange shading indicates the approximate width of the associated structural soil band. (Photos: Björn Embrén)
SAMPLE CASES WITH DRAWINGS, PLANT BED RENOVATION

SECTION EXCAVATION
Scale 1:20 (A2), 1:40 (A4)

Excavation zone, vacuum excavation 2-3 m radius from tree trunk.
NB! Special care is needed when large roots are encountered.
Existing pipes (pipes diagrammatically illustrated).
Existing tree
Existing kerbstone

Roots up to 450 mm can be pruned.
Roots over 450 mm sawed and protected.
Existing superstructure, excavation depth max 1 m.

SECTION BACKFILLING WITH STRUCTURAL SOIL
Scale 1:20 (A2), 1:40 (A4)

Inlet type TLV 2333 (larva) or equivalent,
placed on structural layer for air and water supply.
1 per tree.

Aerated bearing layer
200 mm maximum 32-45 mm.

Surfacing/ superstructure

Gneissite fill layer class B

Air inlet adjusted to 2-15 mm
or coarse crushed rock.

Structural soil with planting soil type D
profile depth <500 mm, humus content 3-6 w% in entire profile
profile depth >500 mm, humus content 4-6 w% in entire profile
Fertilizer: 0-8-16, 8 x year, timing 100/8/60, placed on terrace
and for each layer of structural soil.

Pipe in structural soil
protected with gneissite
filled ground with gravel
as in description.
(Pipes diagrammatically illustrated.)

SECTION BACKFILLING WITH PUMICE
Scale 1:20 (A2), 1:40 (A4)

Loosening of terrace

Pipe/stone 6-12 mm

NOTE
All dimensions in mm unless otherwise stated.

NOTES
When digging deeper than 400 mm,
Fine crushed rock must not be used in the structural
soil profile for adjusting an inliner or concrete bunker.

NOTE
Made in excavation more shallow than 400 mm.
7.3 Large trees - situations with build-up soil

This example describes a situation with large, old trees (trunk circumference > 100 cm) in built-up soil.

Procedure

• Surface layer of asphalt, gravel or concrete slabs around the trees is removed.

• In the immediate vicinity of the trees, 2-3 m radius from the trunk, the risk of encountering large roots and an associated dense root mat is greatest. After removal of the fill material, often under 600 mm depth, a root-friendly excavation method is used to a distance of 2-3 m radius from the trunk. Vacuum excavation is used from the tree trunk outwards.

• Tree roots are pruned and exposed roots protected as described in section 4.3.

• Conventional digging with a mechanical digger can begin at a radius of 2-3 m from the trunk except in the presence of roots greater than 5 cm in diameter.

• Structural soil and aerated bearing layer are laid as in section 6.3. Any roots in the aerated bearing layer are protected with 4-8 mm crushed rock and a geotextile covering.

• Large roots lying in the new bearing layer are protected from sharp stones by surrounding them with 4-16 mm crushed rock and wrapping them in strong geotextile (utility class 3).

• Pavements/surfaces are replaced as described in the plans for the specific project.
Existing limes with roadway overlying the old root system. A minimal centre strip of rock dust and kerbstone has been laid in line with the row of trees, with a width corresponding to the diameter of the existing tree trunks.

Root-friendly excavation is being used here to carefully remove the overlying material and expose the existing root system. A dense mat of fine root system is exposed before the planting bed with aeration structure can be replaced. (Photos: Örjan Stål)
By watering and providing new planting soil, the existing root system exposed by excavation is protected from drought. (Photos: Björn Embrén)

Root-friendly excavation at a street tree on Kungsbroplan in Stockholm in August. Note the brown leaves, showing premature leaf drop and drought damage. (Photo: Örjan Stål)
One year after completion, surface-covering perennials have covered the soil under these trees. The trees have markedly improved growth and greenery. (Photos: Björn Embrén)

Aerated layer of 32-63 mm crushed rock laid on a loosened terrace. The crushed rock layer is not packed down. The crushed rock is intended to provide aeration in the new soil profile. The nutrient-rich planting soil is laid on the layer of crushed rock and hosed in.
SECTION EXCAVATION
SCALE 1:20 (A2), 1:40 (A4)

Inlet, type TLV 9333 Carova or equivalent, placed on structural layer for air and water supply

Air inlet adjusted to 2-4mm or coarse crushed rock

200 mm structural soil with planting soil type D

600 mm structural soil with planting soil type D

humus content 4-6 w% in profile

Fertiliser, 8 m, leaching line 100g/m², placed on terrace and for each layer of structural soil

SECTION BACKFILLING, PAVED AREA
SCALE 1:20 (A2), 1:40 (A4)

Existing pipes (pipes diagrammatically illustrated)

Roots up to 50 mm can be pruned
Roots over 50 mm saved and protected

Excavation depth determined by presence of existing root system

Existing kerbstone

Existing tree

Surface/infrastructure

Geotextile utility class 3

Pipes in structural soil protected with geotextile filled around with gravel as in description (Pipes diagrammatically illustrated)

70 mm surface material, crushed rock 6-32 mm

Aerated gravel zone, crushed rock 8-32 mm

Coir mat KK 5, 700g/m² or equiv.

Plant soil type A in salty conditions

Plant soil type B

humus content 4-6 w%

Roots in structural soil protected with crushed rock 6-8 mm and geotextile

Crushed rock 63-90 mm as aerated layer in planting areas. Fertiliser, 8 m, leaching line 100g/m², placed on terrace and for each layer of crushed rock

Planting soil mixed mechanically with crushed rock volume

SECTION BACKFILLING, PLANTING AREA
SCALE 1:20 (A2), 1:40 (A4)

Ground covering vegetation

Plant soil type A or plants soil type B

Loosening of terrace

NOTE
All dimensions in mm unless otherwise stated
7.4 Large trees - replacement of compacted and/or low nutrient soil

This applies to old and often large trees in areas (lawn, soil and gravel) where the soil is compacted or depleted of nutrients. In restoring gravel surfaces that act as a parking area, an aerated volume with bearing properties can be created by laying layers of crushed rock of gradually decreasing size. For example: A lower layer of 16-32 mm crushed rock is covered with a ‘locking layer’ of 4-16 mm crushed rock. Then comes a wearing layer of 2-4 mm crushed rock. With this method a geotextile layer can be avoided. Geotextile has the disadvantage that it clogs up and thus impedes transport of air and water into the soil profile.

Procedure

• The excavation zone is planned in suitable directions around the trees.

• Root-friendly excavation with pressurised air or water is needed if there are many tree roots and large roots > 30 mm Ø. Excavation continues until the root mat is encountered. This is often at shallow depths of approx. 100 mm. No major damage should be caused to the trees. (Conventional excavation can be carried out to a max depth of 400 mm in soil where only a few or small tree roots < 30 mm Ø are present).

• After removal of the soil, the terrace is loosened using point bursts of compressed air at c/c intervals of 800-1000 mm. If large roots are present, loosening is always carried out with compressed air between the tree roots. If few tree roots are present, mechanical loosening can be carried out with a hand implement.

• Backfilling with planting soil and suitable surface cover, e.g. a bed of summer annuals, lawn or gravel. A well-fertilised humus-rich soil (humus content 5-8 wt-%) is used for backfilling trees in lawned areas. A layer of slow-release fertiliser with an 8 month release period, dose 10 g/m², is laid on the terrace. In excavations deeper than 600 mm, the backfill down to the terrace must consist of 2/3 crushed rock of uniform size (16-32 mm or 63-90 mm) combined with 1/3 planting soil (humus content no greater than 4 wt-%). Having a soil-filled layer of crushed rock down to the terrace improves gas exchange and oxygen supply to the tree roots. To avoid any significant settling of the surface layer when backfilling with a surface layer of gravel, a planting soil with a humus content of max 3-4 wt-% and with well-rotted organic matter (humification score H5-H7 on the von Post scale) is used.
New planting soil type A laid in the trench left by removal of the old road. A new extra nutrient-rich layer of high humus planting soil is laid on the loosened, exposed root system. Completion of new continuous park surface with renovated planting bed areas.

Existing hawthorn tree by an old road in Malmö. The plan is to remove the road and build a continuous strip of park. During test digging no roots were encountered in the road surface layer. Mechanical digging can therefore be used to remove the remaining road layers.

A compressed air lance is used to blow away soil in root-friendly excavation and also to loosen the old surface. The exposed root system is protected with a cover of planting soil. The parking surface is finished off with a permeable surface layer of crushed rock.

Completion of a parking space with permeable surface layer of crushed rock.

An aerated volume with bearing properties for parking. Different locking layers of crushed rock are laid on top of each other. These layers progressively decrease in size the higher up the profile they occur. (Photos: Örjan Stål)
Shallow excavation if many roots or several large roots (>30 mm)
Terrace loosened with compressed air.
Excavation depth turf, normally max 100-150 mm.
Deep excavation if few tree roots or small roots (<30 mm)
Excavation depth gravel area, normally 300-400 mm.

Existing soil, chemically or mechanically compacted.
In some cases excavation depth > 400 mm.

SECTION EXCAVATION
SCALE 1:20 (A2), 1:40 (A4)

Crushed rock, 2-4 mm
Thickness 100 mm at tree trunk

50 mm crushed rock 2-4 mm
50 mm crushed rock 4-16 mm
50 mm crushed rock 16-32 mm
150 mm crushed rock 32-90 mm
300 mm crushed rock 100-150 mm

If no roots are present under terrace, crushed rock packed as for structural soil. Planting soil type D hydrated into layer of crushed rock 100-150 mm. Fertiliser, Multicote 8 month leaching time 100g/m², are posted on terrace.

SECTION MAKING GOOD WITH VEGETATION AREA
SCALE 1:20 (A2), 1:40 (A4)

100 mm crushed rocks 4-16 mm
Coconut matting, KK 5, 700 g/m² or equiv.

Loosening always to be done between large roots.

100 mm mulch

Fertiliser, Multicote 8 month leaching time 100g/m², are posted on terrace.

SECTION MAKING GOOD WITH GRAVEL
FOR TRAFFIC/PARKING
SCALE 1:20 (A2), 1:40 (A4)

Crushed rock, 2-4 mm
Thickness 100 mm at tree trunk

50 mm crushed rock 2-4 mm
50 mm crushed rock 4-16 mm
50 mm crushed rock 16-32 mm
150 mm crushed rock 32-90 mm
300 mm crushed rock 100-150 mm

If no roots are present under terrace, crushed rock packed as for structural soil. Planting soil type D hydrated into layer of crushed rock 100-150 mm. Fertiliser, Multicote 8 month leaching time 100g/m², are posted on terrace.

SECTION MAKING GOOD WITH GRAVEL AREA FOR PEDESTRIANS
SCALE 1:20 (A2), 1:40 (A4)

Loosening always to be done between large roots.

100 mm Crushed rocks 4-16 mm

Coconut matting, KK 5, 700 g/m² or equiv.

Fertiliser, Multicote 8 month leaching time 100g/m², are posted on terrace.

SECTION MAKING GOOD WITH Mulch FOR TURF
SCALE 1:20 (A2), 1:40 (A4)

100 mm mulch

Loosening always to be done between large roots.
7.5 Operations in existing structural soil - excavation and backfilling

Street environments are in constant change in a city. This means that the soil environment for street trees changes. A common operation is excavation work to repair or extend various installations. In this section we give two common examples of excavation in existing structural soil.

**Excavation in existing structural soil**

Excavation in existing structural soil occurs at installation of new pipes, foundations, etc. The work often has to be carried out with a mechanical digger in these situations so excavation must always be carried out with great care and consideration given to prevailing conditions such as tree status, age etc. New cable or pipeline trenches are separated from the existing structural soil with geotextile. The structural soil removed must NOT be tipped back into the trench. The structural soil must be restored according to the requirements for backfilling with structural soil described in section 6.3.

**Procedure**

- Surface layer, upper structure and structural soil are dug out. Conventional excavation with a mechanical digger is permitted outside a 2-3 m radius from the trunk, unless roots larger than 50 mm in diameter are present.
- Pruning of tree roots and protection of exposed roots as described in section 4.3.
- Foundation or pipeline is installed.
- Structural soil and aerated bearing layer are assembled and laid as described in section 6.3. It is important that new geotextile is laid with an overlap of at least 200 mm on the existing geotextile so that fine material is prevented from running down between the aggregates of the structural profile.
- Pavements/surfaces are replaced as described in the plans for the specific project.
Re-laying aerated carrying layer
200 mm crushed rock 32-63 mm

Re-laying structural soil, planting soil type D.
profile depth 600mm: humus content 5-8 wt-% in entire profile
profile depth 600mm: humus content 4-6 wt-% in entire profile
Fertiliser, Multicote 8 month (eaching time 100g/m², at each structural soil layer

SECTION MAKING GOOD AFTER PIPE LAYING
SCALE 1:20 (A2), 1:40 (A4)

Backfill with fine crushed rock for foundation

SECTION MAKING GOOD AFTER LAYING FOUNDATIONS
SCALE 1:20 (A2), 1:40 (A4)

Backfill on structural soil are separated with geotextile
7.6 Protection of tree roots – root wrapping
When installing root wrapping all the operations involved must be carried out in sequence so that root exposure to sun, wind and drought is minimised.

Procedure

• Surface layer, upper layers and soil are excavated away. Root-friendly excavation is carried out close to trees. Conventional excavation with a mechanical digger can often be used outside a 3 m radius of the trunk, unless roots larger than 50 mm in diameter are present.

• Tree roots are pruned as described in section 4.3.

• Tree supports are driven in and coconut matting is fitted against these supports. If necessary, often at greater excavation depths, a stabilising metal mesh (plant nursery net) is fitted.

• Planting soil is filled into the space between the existing root system and the root wrapping.

• The soil material is dampened. The root wrapping is then watered continuously so that it is kept moist.

• The root wrapping is removed when backfilling work begins.
SECTION ROOT COVERING

SCALE 1:20 (A2), 1:40 (A4)

Manual or vacuum excavation
Filled with planting soil type A or type B
watered well so material is saturated.

Coconut matting KKS 700 g/m²

If necessary, wire netting of plant nursery type
can be used as reinforcement.

Wooden pole c/c 1500-2000

Roots pruned with hand tool

Pipe culvert

NOTES
All data in mm unless otherwise specified.
DESCRIPTIONS
8 DESCRIPTIONS

The aim of the text below is to provide guidance to planners producing bulk descriptions for projects containing elements of planting and/or plant bed renovation. The text is both advisory and specific in nature. The text must therefore be adapted and complemented with case-specific information.

References to e.g. case-specific drawings and appendices in the following are marked with an x. Advisory text is marked with red type.

The current edition of the City of Stockholm Technical Handbook is abbreviated to ‘TH 2007’.

The text is associated with AMA Installation 07 (Codes BBD SURVEYING and BBE STAKING OUT are associated with AMA Installation 98).

Bulk description codes below are associated with AMA Installation 98

B  PREPARATION WORK, PRECAUTIONARY WORK, SANITATION WORK, MOVING, DISMANTLING, DEMOLITION, CLEARING ETC.

Texts in AMA Installation 07 apply, with amendments and additions according to TH 2007, Parts 1 and 2 and Part 5 procedure 13.x and Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x

BB  PREPARATION WORK

BBB  INVESTIGATIONS CARRIED OUT, ETC.

BBB.1  Soil and water conditions etc.

The work will be carried out in existing street site, park site or on new ground.

BBB.23  Text digging carried out

State whether test digging has been carried out and its results (forms the basis for how the work should be carried out). If not, specify under code BBC.1 that test digging must be carried out.

BBB.3  Existing installations, etc.

BBB.32  Existing pipes and cables

Existing underground and aerial pipes and cables are recorded in Stockholm Water’s compilation map. The contractor must obtain essential knowledge of existing pipes and cables. See also BCB.31 and BCB.32. Pipe and cable maps must be ordered from Stockholm Water by the contractor.

I  Compilation map 1:200, examined.

Before excavation work begins, contact must be made with pipe and cable owners to map the exact position of existing pipes and cables. If further pipes and cables are encountered within the work area, their owner and the client must be informed immediately.

Existing pipes and cables must be presumed to be in operation during the work period unless otherwise stated.

BBC  INVESTIGATIONS etc.

BBC.1  Investigations of soil and water conditions etc

The contractor in consultation with the client carries out thorough investigations, test digging to determine the extent of roots and their thickness, the composition of the soil, the thickness of reinforcing layers etc. Test digging must be carried out according to section 4.2 in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x or according to other instructions.

BBC.17  Damage risk assessment

Before work begins, the contractor must organise a joint inspection of street or park land. Minutes must be taken by the contractor. Measures must be taken to protect neighbouring buildings, infrastructure, pipes, cables and land survey benchmarks. During the entire construction period, the contractor is responsible for any damage that may arise to existing infrastructure, buildings, pipes and cables, and equipment.

BBD  SURVEYING

Texts in AMA Installation 98 apply, with amendments and additions according to TH 2007, Parts 1 and 2 and Part 5 procedure 13.x

BBD.1  Surveying land, infrastructure etc.

The standpoints for surveying in plane and level are polygonal and fixed points in the City of Stockholm’s coordinate network and elevation system. Data on polygonal and fixed points are supplied by the client.

The extent/scope of the planting bed must be surveyed. This survey must also show the thickness of different layers of material, the location on inlets, etc. When sketches and drawings are submitted, these must state the name of the project, the contractor’s details, date and signature (fully legible name) of the person responsible for the
BBE  STAKING OUT
Texts in AMA Installation 98 apply, with amendments and additions according to TH 2007, Parts 1 and 2 and Part 5 procedure 13.x

BBE.1 Staking out infrastructure and building foundations?
Data on polygonal and fixed points are obtained from the client.

BC  PRECAUTIONARY WORK, TEMPORARY ARRANGEMENTS AND MEASURES ETC.
Texts in AMA Installation 07 apply, with amendments and additions according to TH 2007, Parts 1 and 2 and Part 5 procedure 13.x

BCB  PRECAUTIONARY WORK FOR INFRASTRUCTURE
The contractor must take those measures necessary to protect nearby buildings and infrastructure, plus pipes and cables, polygonal and fixed points, etc. from damage. Polygonal and fixed points or private pipes damaged during the course of the work must be repaired through the client and at the expense of the contractor. Existing pipes and cables must be presumed to be in operation during the work period unless otherwise stated.

BCB.1 Handling of water
BCB.11 Temporary diversion of water

BCB.2 Temporary measures on neighbouring buildings or infrastructure
The contractor must take those measures necessary to protect nearby buildings and infrastructure, sewage pipes, electricity, TV and optical cables, civil defence structures and polygonal and fixed points, etc. from damage. During the entire project period, the contractor is responsible for any damage caused by the contractor that can arise in existing infrastructure. Before any action is taken on neighbouring buildings or infrastructure, the client must be contacted.

BCB.3 Temporary measures for protection of pipes and cables, etc.
The contractor must obtain the necessary knowledge of existing pipes and cables so that these are not damaged. It is the duty of the contractor to ensure that the function of existing pipes and cables is maintained. In work that affects existing pipes and cables, the owner of these must be informed in good time before the work begins. After consultation with the client and the owner of pipes and cables, the contractor must carry out the necessary measures for temporary displacement, supporting or hanging of existing pipes and cables. The owner of pipes and cables retains the right to carry out this displacement or hanging on a support structure provided by the contractor. If optical cable is encountered, the owner of this must be contacted immediately for information on suitable measures. The instructions of the cable owner must be followed unconditionally. Before any excavation work may begin, relevant pipe and cable maps must be obtained from the pipe/cable owner, recompensed according to the position of existing pipes and cables must be staked out by, and at the expense of, the contractor.

BCB.31 Measures for underground pipes
The instructions in TH 2007, Part 5, section 54 must be followed.

BCB.32 Measures for underground electricity and telecommunications cables
Before excavation begins, measures for protection of existing cables must be carried out in consultation with the client and cable owner. New infrastructure must be put in place before existing infrastructure is demolished.

BCB.4 Temporary protection of soil, vegetation, land survey points etc.
Soil and vegetation to be retained must be protected so that no damage is done to tree crowns, trunks, roots, rootzone and the soil around trees. This refers to all types of damage, including compaction (compression) of the soil and other mechanical, chemical, biological and aesthetic damage, e.g. damage to roots and general fouling as a result of leaks, etc. Protection measures must be put in place during staking out for ground work, before establishment work and/or demolition and clearing work begins. State if case-specific protection has to be provided.

BCB.412 Protective fencing-off of individual trees
To be done according to TH, Part 2 Infrastructure, code BCB.43, or state case-specific terms.

BCB.413 Protective fencing-off of vegetation areas
The fence must consist of at least 2 m high construction site fencing of type Troax or similar, which must be fixed in place so that it cannot be penetrated or moved. The fence must not be placed closer to the tree trunk than the equivalent of the outer limit of the crown plus 1 metre, unless otherwise agreed with city representatives at the site. Or state case-specific terms.

BCB.42 Blocking off soil surface
State if a certain part of the surface should be fenced off during construction, e.g. to avoid compression.

BCB.43 Lagging of trees, impact protection
Trees within the work area that risk being damaged must be protected. The protection must consist of at least 4 sections of ~2 m high and ~1 m wide fence of type Troax or similar with two car tyres on the inside of each gate as shock absorbers for the trunk. The fence sections must be hooked together. They must not be nailed to the
tree.

**BCB.44 Protection of soil surface in tree and bush rootzone**

Text under this code and heading in AMA 07 applies, with the following addition:

By tree rootzone is meant all ground out to 2.5 m outside the horizontal outer dimensions of the tree crown. The rootzone must not be damaged. See also BCB.51. The contractor must not pass over the rootzone with heavy vehicles or set up storage areas for goods and materials within this zone. On vegetation areas, 32-63 mm crushed rock is used, laid on geotextile. The surface is levelled off with 0-32 mm gravel. State case-specific terms.

**BCB.5 Measures after damage to vegetation**

Text under this code and heading in AMA 07 applies, with the following amendments and additions:

Roots that are damaged and exposed by digging must be handled according to section 4.3 Plant handling - pruning and protection of tree roots in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

**BCB.51 Measures in tree and bush rootzone**

Roots exposed by digging must be handled according to section 4.3 Plant handling, pruning and protection of tree roots in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x. Sheet piling in the rootzone must be done with sharpened sheets.

**BCB.52 Measures in tree crown**

Text under this code and heading in AMA 07 applies, with the following additions: Branches that are at risk of being damaged should be pruned in advance. If damage still occurs to branches thereafter, the damaged parts must be pruned away at once, so that clean, sharp cut surfaces are created. Pruning must be carried out in consultation with city representatives at the site.

**BCB.7 Measures for general traffic (add case-specific codes)**

**BED DEMOLITION**

Environmentally hazardous waste must be separated at source according to municipal regulations. Material that will be re-used or that remains the property of the client must be cleaned and separated out.

**BED.1 Demolition of infrastructure (add case-specific codes)**

Demolition must proceed from the tree trunk out. If tree roots are discovered (e.g. in bedding sand, bearing or reinforcing layers), excavation must be carried out using root-friendly methods, see CBB.14

**C TERRACES, PILING, GROUND ENGINEERING, STOCKS IN SOIL ETC.**

Texts in AMA Installation 07 apply, with amendments and additions according to TH 2007, Parts 1 and 2 and Part 5 procedure 13.x. In pipe and cable excavations, TH 2007, Part 6 section 6051-6052 must be observed.

**CB EXCAVATION**

**CBB SOIL EXCAVATION**

Text under this code and heading in AMA Installation 07 applies, with the following additions: Excavation in the tree rootzone must be carried out with extreme care as described in section 4.3 so that tree roots are not damaged. If tree roots are discovered, excavation must be carried out with a suitable excavation method as described in sections 4.4 and 7.2 of Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

When excavating around existing lamp posts, the posts must be supported or secured in some other way. Excavation closer than 1 m to existing pipes or cables must be carried out by hand. For excavation closer than 1 m to existing pipes or cables and when the pipe or cable has to be undermined and suspended, contact must be made with the pipe/cable owner. Exposed cables must be protected from damage according to the owner’s instructions. If damage arises to pipes or cables, this must be reported immediately to engineers authorised by the pipe or cable owner/city.

**CBB.11 Soil excavation for road, lot, etc.**

**CBB.112 Soil excavation category B, for road, lot, etc.**

Excavation must proceed from the tree trunk out. Case B.

**CBB.14 Soil excavation for vegetation area**

Text under this code and heading in AMA Installation 07 applies, with the following additions: Excavation for vegetation areas must be carried out in such a way that the terrace base is not compacted. State case-specific terms for how excavation should be carried out (3 options).

1. Mechanical digging, case B
2. Manual digging, case B

**CE BACKFILLING, LAYERS IN SOIL, ETC.**

**CEB BACKFILLING for ROAD, BUILDING, BRIDGE, ETC.**
CEC BACKFILLING for PIPELINE, BUNKER, ETC.
CEC.3 Filling around objects
CEC.33 Filling around barriers, inspection manholes, etc.
Refers to filling around air inlets: to be carried out according to Appendix 9.9 in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x (with structural skeleton and aerated bearing layer). Case B.

D SOIL SURFACE STRUCTURE, INFRASTRUCTURE ADJUSTMENT ETC. (add case-specific codes)

DB LAYER OF GEOTEXTILE, BUBBLE WRAP, ETC.
DBB LAYER OF GEOTEXTILE
DBB.1 Material-separating layer of geotextile
DBB.111 Material-separating layer of geotextile under backfill for road, lot, etc.
.1 Laid over the aerated carrying layer. Utility class 3.
.2 Laid as material-separating layer of coconut matting. KK5.

DC SOIL SURFACE STRUCTURES (add case-specific codes)
DCB UNBOUND SURFACE STRUCTURE LAYERS FOR ROAD, BRIDGE, ETC.
DCB.2 Reinforcing layers for road, lot, etc.
DCB.212 Reinforcing layers category B for upper structure with flexible construction and with bitumen-bound wearing layer, concrete slabs, etc. Structural skeleton (crushed rock) regulated under DCL.13.

DCB.3 Unbound bearing layer for road, lot, etc.
DCB.31 Unbound bearing layer for paved surfaces
DCB.312 Unbound bearing layer category B for paved surfaces
Applies also to DCB.322, areas with unbound wearing layer. Case B.
.1 State case-specific thickness, refers to bearing layer above aerated bearing layer.
.2 Aerated bearing layer 32-63 mm crushed rock thickness 200 mm, as in Appendix 9.9 Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x, regulated under DCL.13.

DCG SOIL COVERINGS OF COBBLESTONES, CONCRETE SLABS, CONCRETE BLOCKS, TILES, ETC. (add case-specific codes)

DCL SURFACE STRUCTURE LAYERS FOR VEGETATION AREAS
DCL.1 Planting bed

DCL.1 Planting bed type 1 and 2, added soil
Text under this code and heading in AMA Installation 07 applies, with the following amendments and additions:
General requirements on planting soil according to AMA 07, Table DCL/1 are rescinded and replaced by requirements on composition, properties and nutrient content according to the following codes and headings.
The soil must be applied in such a way that the planting bed and terrace are not compacted.
Soil analysis must be carried out on the material applied to create the planting bed. For volumes exceeding 30 m³, representative samples must be taken for every 50th cubic metre. In those cases where the total volume of soil material added is lower than 30 m³, soil analyses carried out by the supplier can be submitted to the city representative, provided that the analysis is not older than one month.

DCL.1 Planting bed for tree hole in paved area, added soil
State case-specific terms for type of soil (type A, type B, type C or type D) and thickness according to Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DCL.1 Planting bed for trees and bushes in vegetation area, added soil
State case-specific terms for type of soil (type A, type B or type C) and thickness according to Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DCL.1 Planting bed for perennials, added soil
State case-specific terms for type of soil (type A, type B or type C) and thickness according to Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DCL.1 Planting bed for lawn, added soil
General requirements on planting soil according to AMA 07, Table DCL/1 must be met as regards requirements on soil for planting bed for lawn. State case-specific terms for type of soil (type B) and thickness according to Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.
DCL.12 Planting bed type 3 and 4, existing soil
Soil improvement, liming and fertilisation must be carried out so that requirements according to Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x are fulfilled.

DCL.121 Planting bunkers, etc
State case-specific terms for individual equipment. Concrete bunkers are bedded in 2-4 mm crushed rock according to Appendix 9.9 in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DCL.13 Planting bed for structural soil


Requirements on crushed rock. Material: Crushed rock stone size 100-150 mm.


2. Fertilisation: For every layer of structural material laid, nutrients must be applied, replaced under code DCL.23.

3. Aerated bearing layer: When the structural soil structure has reached the planned thickness, an aerated bearing layer of 32-63 mm crushed rock is applied.

4. Geotextile: Geotextile is laid on the aerated carrying layer, replaced under code DBB.131.

.1 Structural skeleton, 100-150 mm crushed rock incl. planting soil type D thickness= case-specific.

.2 Aerated bearing layer of 32-63 mm crushed rock, thickness= 200 mm.

DCL.14 Specialist planting beds
DCL.141 Planting bed on concrete basement
State case-specific terms for type of soil (type C) and thickness according to Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DCL.143 Planting bed for percolation or infiltration bunker, etc.
DCL.2 Preparation for sowing, planting etc.

DCL.21 Soil improvement of planting bed
Soil improvement must be carried out on the basis of soil analysis so that the requirements set according to DCL.12 are fulfilled.

DCL.22 Liming
Liming must be carried out so that the requirements set for pH value according to DCL.12 are met in the soil.

DCL.23 Fertilisation
Fertilisation must be carried out at least 14 days before sowing and planting and kept up until the establishment inspection so that the requirements set for nutrient content according to DCL.12 are fulfilled.

DCL.25 Levelling of planting bed
Text under this code and heading in AMA Installation 07 applies, with the following amendments and additions:

Stones larger than 16 mm on the surface of lawns and larger than 70 mm on other planting areas and other foreign objects must be removed.

The variation in level for surveying with a 3 m levelling rod must be:
For planting area 50 mm
For lawn area 30 mm.

Level tolerance ± 30 mm (applies for both lawn and planting areas).

DD VEGETATION AREAS, SOWING AND PLANTING, ETC.
Text under this code and heading in AMA Installation 07 applies, with the following amendments and additions:

The planting bed must be approved by the city representative before sowing and planting may begin.

DDB SOWING, PLANTING, ETC. (state case-specific terms)
DDB.1 Sowing and turf-laying
DDB.11 Sowing

DDB.111 Sowing of lawn
Text under this code and heading in AMA Installation 07 applies, with the following amendments and additions:

Planting bed for lawn must be raked level and lightly rolled with a lattice roller before sowing. Grass seed must be distributed evenly across the entire surface, with approx. 2 kg certified grass seed per 100 m². After sowing and seed covering, the surface must be rolled with a solid smooth roller.
DDB.12 Turf-laying etc.
DDB.121 Turf-laying with cultivated grass sods
DDB.122 Turf-laying with recycled site vegetation
DDB.123 Turf-laying with cultivated moss, sedum, herb and grass vegetation
DDB.124 Laying with established shoreline matting, roll, etc.
    To be carried out according to the manufacturer/supplier’s terms and instructions.

DDB.2 Planting nursery plants

DDB.221 Planting deciduous trees
    With root ball and trunk circumference; state case-specific terms

DDB.221 Support and protection for plants

DDB.2 Support for plants

DDB.221 Support for upright trees
    Supports are driven in before backfilling of planting soil. State case-specific terms.
    Tying-in of large trees should be carried out according to TH 2007, Part 1 Drawings and design, sample drawing TH0012.

DDB.24 Protection of soil surface from drought
    Texts in AMA Installation 07 apply, with amendments and additions according to TH 2007.

DDD Complementary upkeep

DDD.1 Loosening, mechanical weed control around trees, bushes, etc.
    To be carried out according to text under section 5.3 Work description for guarantee upkeep in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DDD.14 Watering of trees, bushes, etc.
    To be carried out according to text under section 5.3 Work description for guarantee upkeep in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

DDD.21 Grass cutting, lawn mowing
    Lawn mowing must be carried out for the first time when the grass is 75-100 mm high and thereafter at least once when the grass is again 75-100 mm high. Max. 1/3 of the grass length may be cut away on any occasion.

DDD.22 Weed control in lawns
    Weed control in lawns must be carried out regularly, at least twice a month during the growing season (May-October).

DDD.23 Topdressing of lawns
    Grass must not suffer from nutrient deficiency and if necessary after analyses must be fertilised with a suitable fertiliser. Before fertilisation, consultation must be carried out with city representatives at the site.

DDD.24 Watering of lawns
    Lawns must be watered so that the soil is constantly moist down to 250 mm depth.

DE Construction upkeep

DHB Upkeep of soil construction during the guarantee period

DHB.3 Uptake of vegetation areas, etc. during the guarantee period
    Weed control must be carried out by hand. With the agreement of the city authorities, some chemical weed control may be permitted with biologically degradable herbicides Class 1. Fertilisation must be carried out if necessary after analysis.
    Vehicles and equipment must be of a type and used in such a way as to avoid soil compaction.
    The guarantee period is 2 years. A-prices must refer to costs for 2 years.
DHB.311 Upkeep of planting areas during the guarantee period

Upkeep of vegetation areas must be carried out according to text under section 5.3

DHB.312 Upkeep of bushes etc. during the guarantee period

During the guarantee period, normally no pruning of newly planted bushes is carried out. Dead, diseased or damaged plant parts must be removed continually. Root and trunk shoots must be removed. If pruning is necessary, it must be carried out so that the natural character of the plant is retained. All pruning must be carried out in consultation with city representatives at the site.

Tying-in of climbing plants must be checked regularly during the establishment phase.

DHB.32 Upkeep of lawns during the guarantee period


PDH.1 Level adjustment of manholes

1. Adjustment of existing cover in conjunction with plant bed renovation work.
2. Height adjustment of existing cover with the same intermediate sections as the rest of the inlet + 15-120 mm.

YC NOTIFICATION AND APPLICATION PROCEDURES, TECHNICAL DOCUMENTATION, ETC. FOR INFRASTRUCTURE

The contractor must provide and submit data support for relation procedures. Data support for relation procedures must be submitted to the client at notification for final inspection. The drawings and measurement data submitted to the client must be labelled with the project name, the contractor’s details, the date and legible signature of the person approving the documents.

The contractor must measure and report the extent of the planting bed area, the number of air inlets. Documentation of structural soil construction must be submitted to the client with photos and a signed worksheet from the site foreman as described in section 5.1 Monitoring programme during construction in Planting Beds in the City of Stockholm. A Handbook, dated 2009.02.23, procedure 13.x.

YE VERIFICATION OF FULFILLMENT OF REQUIREMENTS ON PRODUCTS

Adjustment of inlet

At most three adjustor sections may be used and the combined height of the adjustor sections and slider plate must not exceed 150 mm.

Adjustments of level with combined height >200 mm must be carried out with intermediate sections.

Telescopic covers must be placed so that they are 0-5 mm below the finished surface. Fixed covers must be adjusted with the help of adjustor sections so that they lie 0-10 mm below the planned pavement level. The pavement is then adjusted so the cover ends up 0-5 mm below the finished surface.

PDH.5 Stormwater inlet in sewer

PDH.51 Stormwater inlet of concrete

PDH.519 Air inlet of concrete or cast iron


PC CONNECTIONS; ATTACHMENTS, CORROSION PROTECTION TREATMENTS, TESTS, ETC. IN PIPELINE IN THE CONSTRUCTION

PD INLETS ETC. IN THE GROUND

P APPARATUS, PIPES AND CABLES, ETC. IN PIPELINE SYSTEM OR NETWORK

PB PIPES AND CABLES IN THE CONSTRUCTION

PBB PIPES AND CABLES IN TRENCHES (state case-specific terms)

PCB CONNECTIONS, ATTACHMENTS, CORROSION PROTECTION TREATMENTS, TESTS, ETC. IN PIPELINE IN THE CONSTRUCTION

PDB MANHOLES ON SEWERS

PDB.5 Stormwater inlet in sewer

PDH Attachments to inlet

Attachments and replacement parts must fulfil the same requirements on materials and procedures as the inlet itself.
9. APPENDICES

Particle size distribution graphs for planting soils, etc.
The planting soil must have a humus content of 5-8 wt-% to a depth of 400 mm. Mineral soil, at depth >400 mm, must have a humus content of < 2 wt-%.
The planting soil must have a humus content of 5-8 wt-% to a depth of 400 mm. Mineral soil, at depth >400 mm, must have a humus content of < 2 wt-%.

### Soil Type Distribution

<table>
<thead>
<tr>
<th>Particle Size Distribution</th>
<th>Project no.</th>
<th>Client</th>
<th>Sampling date</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0007</td>
<td>0.0008</td>
<td>0.0009</td>
<td>0.0010</td>
</tr>
<tr>
<td>0.0013</td>
<td>0.0014</td>
<td>0.0015</td>
<td>0.0016</td>
</tr>
<tr>
<td>0.0019</td>
<td>0.0020</td>
<td>0.0021</td>
<td>0.0022</td>
</tr>
<tr>
<td>0.0025</td>
<td>0.0026</td>
<td>0.0027</td>
<td>0.0028</td>
</tr>
<tr>
<td>0.0031</td>
<td>0.0032</td>
<td>0.0033</td>
<td>0.0034</td>
</tr>
<tr>
<td>0.0037</td>
<td>0.0038</td>
<td>0.0039</td>
<td>0.0040</td>
</tr>
<tr>
<td>0.0043</td>
<td>0.0044</td>
<td>0.0045</td>
<td>0.0046</td>
</tr>
<tr>
<td>0.0049</td>
<td>0.0050</td>
<td>0.0051</td>
<td>0.0052</td>
</tr>
<tr>
<td>0.0055</td>
<td>0.0056</td>
<td>0.0057</td>
<td>0.0058</td>
</tr>
<tr>
<td>0.0061</td>
<td>0.0062</td>
<td>0.0063</td>
<td>0.0064</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site</th>
<th>Sample no.</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The planting soil for normal soil conditions - Type B

**Soil Nutrient Analysis by AL-method**

<table>
<thead>
<tr>
<th>Site</th>
<th>Sample no.</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Table:**

<table>
<thead>
<tr>
<th>Project:</th>
<th>Planting soil type B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td></td>
</tr>
<tr>
<td>Sample no.</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td></td>
</tr>
</tbody>
</table>

---

**Diagram:**

- Particle size distribution
- Soil nutrient analysis by AL-method
- Humus content levels
- Soil types (clay, silt, sand, gravel, stone)

---

**Details:**

- Client: [details]
- Project: [details]
- Sampling date: [details]
- Site: [details]
- Sample no.: [details]
- Name: [details]

---

**Footer:**

- SWECO GEOLAB
- 2009.02.13 GH100112 Planting soil type B
- Particle size distribution

---

**Note:**

- The diagram shows the distribution of particle sizes within the planting soil sample.
- Humus content ranges are specified for different depths and soil types.
- Soil nutrient analysis results are presented in a table format.
The planting soil must contain at least 40 wt-% pumice.

The planting soil must have a humus content of 5-8 wt-% to a depth of 400 mm.

Mineral soil, at depth >400 mm, must have a humus content of <2 wt-%.

### Particle size distribution

<table>
<thead>
<tr>
<th>Type</th>
<th>Clay</th>
<th>Fine sand</th>
<th>Med. sand</th>
<th>Coarse sand</th>
<th>gravel</th>
<th>Fine gravel</th>
<th>Med. gravel</th>
<th>Coarse gravel</th>
<th>Stone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>5.0-7.0</td>
<td>6.0-8.5</td>
<td>7.0-9.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Li</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.5-2.0</td>
<td>1.0-3.0</td>
<td>2.0-5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>4.0-8.0</td>
<td>6.0-12.0</td>
<td>8.0-16.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Si</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulf</td>
<td>0.0-0.1</td>
<td>0.1-0.2</td>
<td>0.2-0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.01-0.06</td>
<td>0.02-0.06</td>
<td>0.06-0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.001-0.002</td>
<td>0.002-0.004</td>
<td>0.004-0.006</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.005</td>
<td>0.006</td>
<td>0.007</td>
<td>0.008</td>
<td>0.009</td>
<td>0.01</td>
<td>0.015</td>
<td>0.02</td>
<td>0.025</td>
</tr>
</tbody>
</table>

**Note:** The diagram and tables provide a visual representation of the soil properties and analysis results for different particle sizes and elements.
The planting soil must have a humus content of 5-8 wt-% to a depth of 400 mm. Mineral soil, at depth >400 mm, must have a humus content of <2 wt-%.
9.5 Particle size distribution curve - fraction for aerated bearing layer

Avvikelse på stenstorlek max 5 % gäller både ovan respektive under angivet storleksspann 32-63 mm.

Minsta tillåtna stenstorlek, 16 mm
Största tillåtna stenstorlek, 80 mm
9.6 Particle size distribution curve – structural fraction
(MISSING)
### 9.7 Example – Assessment Table, Compensation for Damage to Trees

**Compensation for damage to trees**

**Base info.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Elm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID.no</td>
<td>1</td>
</tr>
<tr>
<td>Tot. Compensation</td>
<td>250000 SEK</td>
</tr>
</tbody>
</table>

**Calculating compensation for damage to branches**

<table>
<thead>
<tr>
<th>Damaged branches</th>
<th>% of compensation sum</th>
<th>SEK</th>
<th>(No. of damaged branches)*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch ø 3-5 cm</td>
<td>0.5%</td>
<td>1250</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Branch ø 5-10 cm</td>
<td>10.0%</td>
<td>2500</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Branch ø &gt;10 cm</td>
<td>20.0%</td>
<td>5000</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

For damage >30% of all branches > ø 5 cm, full compensation is due. **0 SEK**

**Calculating compensation for damage to trunk**

<table>
<thead>
<tr>
<th>Damage to trunk, only bark damage</th>
<th>% of compensation sum</th>
<th>SEK</th>
<th>(No. of injuries to trunk)*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10 cm² damaged bark</td>
<td>1.00%</td>
<td>2500</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10-200 cm² damaged bark</td>
<td>3%</td>
<td>1250</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>200-400 cm² damaged bark</td>
<td>40%</td>
<td>10000</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>200-400 cm² damaged bark</td>
<td>100%</td>
<td>25000</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Damage to trunk, bark and wood damage</th>
<th>% of compensation sum</th>
<th>SEK</th>
<th>(No. of injuries to trunk)*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 cm² damaged bark and wood</td>
<td>2%</td>
<td>5000</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>10-200 cm² damaged bark and wood</td>
<td>15%</td>
<td>37500</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>200-400 cm² damaged bark and wood</td>
<td>50%</td>
<td>12500</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>&gt;400 cm² damaged bark and wood</td>
<td>100%</td>
<td>25000</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**Calculating compensation for damage to roots**

<table>
<thead>
<tr>
<th>Damaged roots</th>
<th>% of compensation sum</th>
<th>SEK</th>
<th>(No. of damaged roots)*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root ø 3-5 cm</td>
<td>0.5%</td>
<td>1250</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Root ø 5-10 cm</td>
<td>10.0%</td>
<td>2500</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Root ø &gt;10 cm</td>
<td>20.0%</td>
<td>5000</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**TOTAL compensation:** **0 SEK**

---

**AF-code for Assessment Table, Compensation for Damage to Trees according to AB04**

AFC.513 Compensation for damage to vegetation

For assessment of compensation for damage to trees, Appendix 9.7 Assessment Table, Compensation for Damage to Trees, should be used. See also text in section 5.2 Assessment of compensation for damage to trees in Planting Beds in the City of Stockholm, A Handbook
9.8 Checklist for construction foreman – monitoring programme

The checklist below can be regarded as support for the construction foreman in dialogue with the contractor.

Monitoring stages in projects involving establishing vegetation

• Check and review of construction documents. Be particularly alert to specially drawn details for soil features such as tree planting holes. Check the minimum dimensions and compare against suggested tree sizes to ensure that root balls will actually fit in the suggested holes.

• Review essential parts of the project concerning tree planting and retention of existing vegetation with contractor personnel. For example construction of structural soil and plant bed renovation with vacuum excavation.

• Soil sampling and inspection of all stone material, e.g. structural material and aerated bearing layer.

• Draw up a procedure for submission of photodocumentation of key stages according to section 6 from contractor to foreman.

• Continuous inspection on-site during key stages.

• Check of deliveries of plant material. Check also plant storage. This is particularly important in cold weather at temperatures around zero.

• Monitoring restoration measures and guarantee upkeep.
9.9 STRUCTURAL SOIL – DESCRIPTION OF PROCEDURE, SHORT VERSION

Procedure for structural soil construction

1. Adjust height of planting bunkers and air and infillation inlets with 2-4 mm crushed rock. Do NOT use sand or gravel.

2. Lay crushed rock (100-150 m crushed rock) in layers of 250-300 mm and pack these down with 4-5 passes with a levelling plate.

3. It is very important to finish packing before the soil is hosed in to prevent soil being compacted between the stones.

4. Lay the soil in layers of max 20 mm and hose it down into the structural volume (crushed rock).

5. Use small amounts of water and high pressure.

6. Add more soil and hose it down until the crushed rock is saturated. Around 25-30% planting soil can fit in the structural volume (10 m³ crushed rock = 25-3 m³ soil).

7. The crushed rock in the filled layer must be visible before the next layer of crushed rock is added. This is to avoid compaction of the planting soil.

8. Lay slow-release Multicote fertiliser with 8-month release time on every layer of the structural soil. 100 g/m² (= one handful/m²).

9. When the full height of the structural profile is reached, lay the aerated bearing layer of 32-63 mm crushed rock, pack it down well and cover it with geotextile.

10. The upper structure is completed with a layer of gravel and paving.

11. Planting soil is added to the planting hole and the tree is planted.

New planting of trees in paved area, illustrated here with sub-vegetation option.
Principle section, scale 1:50

The pictures above illustrate the procedure for structural soil construction, from laying and compressing the crushed rock layers for the structural volume, through protection of existing pipelines, placement of air inlets hosing in planting soil, fertilisation, laying aerated bearing layer, laying material-separating geotextile and gravel, placement of drain covers for water gutters to final placement of the tree grid and paving.