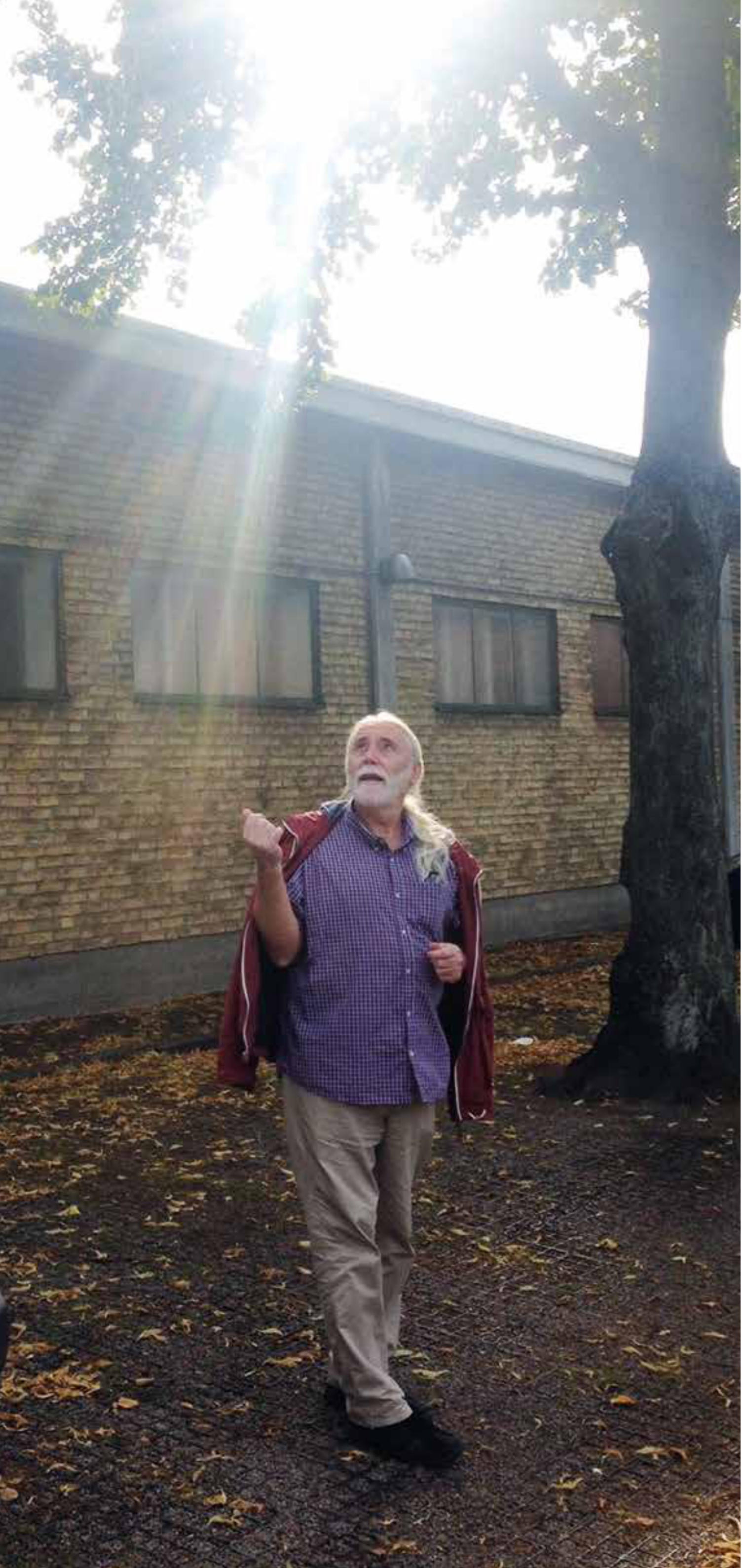
Stockholms stad

Plant beds in Stockholm city
– a handbook 2017

stockholm.se/trad



Preface

Many of the tree plantations in Stockholm were carried out at the end of the 19th century. At that time, the soil materials in the streets were still open and the roots could spread relatively freely under ground. Since then, the streets have been paved, a number of pipes have been laid in the ground and the root system of the trees has often suffered major damage from excavation and compacted backfill. This means that the city's trees no longer get air and water to grow and deliver the ecosystem services they have previously. When the Traffic Office conducted an overall status assessment of street traffic in Stockholm in 2001, it showed that two-thirds of all trees in the inner city were dead or dying. Therefore, a solution was needed to get the trees to recover. Over the years, many different technologies and materials have been tested.

The system used today to build plant beds in Stockholm has been inspired by various structural soil and plant bed projects in Europe.

The most important sources of inspiration are sites in the Netherlands, research on structural soil conducted at the University of Hanover, Germany, and the various projects led by Klaus Schröder in Osnabrück. These structural soils are plant beds built with the help of stones that provide bearing for traffic and at the same time create cavities that allow the trees to spread their roots. An article in "Outdoor Environment" (1998) describes an aeration layer on top of the Danish variant of structural soil, so-called gardener macadam. This, together with the booklet "The oxygen requirement of plant roots in relation to soil aeration" has inspired the Stockholm model's design with an aerated bearing layer and aeration wells. This part of the structure allows gas exchange for the root system, as well as intake of stormwater to meet the trees' need for air and water in hardened surfaces. The Stockholm model strives to use as much renewable and local material in the plant bed as possible. Macadam from local infrastructure projects is used in most construction. Biochar produced locally from, among other things, garden waste is used together with compost mixed with macadam as a plant substrate.

The city's high proportion of hardened surfaces creates large flows of stormwater that must be managed in some way - in order not to overload the drainage network. Different types of plant beds provide good opportunities for delaying stormwater by utilizing the voids in the material while the stormwater is watering the trees.

Tests conducted by the National Road and Transport Research Institute VTI in 2014 show that structural soil provides good sustainability and can be used under lanes on streets and parking lots, as well as under pavements.

Stockholm City Tree specialist Björn Embrén in an enlightened moment. Photo Magdalena Möne.

Contents

The contents and use of the manual

The handbook is for anyone who plans, builds and manages environments with trees for the City of Stockholm and should be a support for the planning and construction of new plant beds as well as for measures close to existing trees. Plant beds in Stockholm are subordinate to the Tree Strategy Stockholm and will be used in conjunction with the Technical Manual and AMA Construction. Plant beds in the City of Stockholm are coordinated with the AMA version described in the Technical Manual regarding AMA codes. The manual is available on the Stockholm City website and is updated regularly.

Overview – contents

1. Urban plant beds

The manual begins with a description of the conditions of the city trees and the problems that often arise. Methods for the new planting of trees developed in Stockholm are also described.

2. Remedies for existing trees

Chapter 2 describes what is important to consider when working near existing trees. It also describes how plant bed remodeling works.

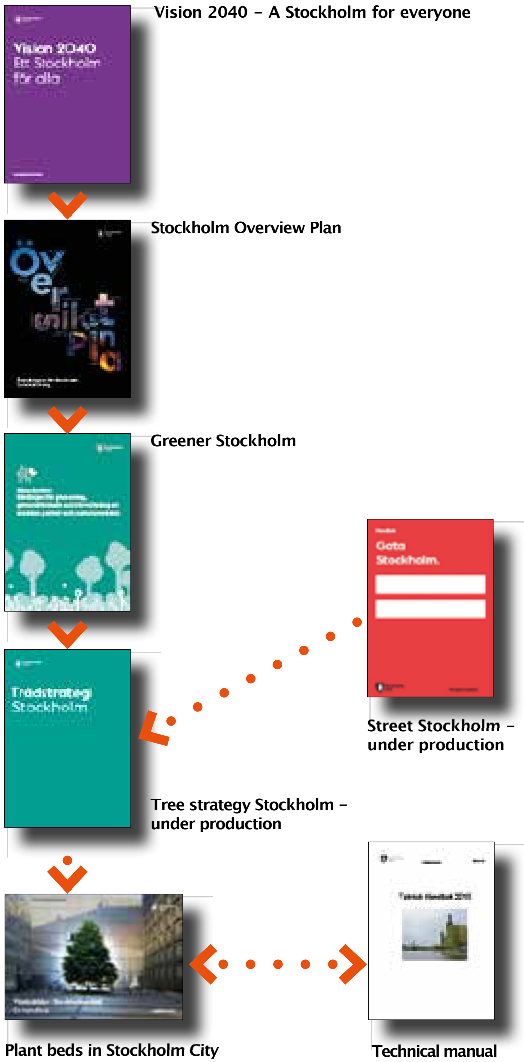
3. Control, penalty and maintenance

Chapter 3 describes procedures for checking during work, procedures for guaranteeing and watering, and Stockholm City's policy regarding penalties for damages.

Attachments

The manual includes appendices such as detailed plant descriptions and type drawings. These types of drawings should always be used in projects with the City of Stockholm as a client.

Overview – governing documents



When do I use the manual?

Pre-study or Planning

What to think about when planning - page 14.

Planning and evaluation of actions (for existing trees) - page 19.

Design

What to consider when planning and designing - page 14.

Control program guidelines - page 24.

Appendix: Drawings

Implementation

Things to keep in mind when planting - page 17.

Root protection - page 20.

Control program guidelines - page 24.

Appendix: Execution descriptions

Appendix: Control program

Completion

Amount of penalty for damages - p. 25.

Warranty maintenance - page 25.

Irrigation - page 27.

Concepts used in this manual

Leveling layers are laid between the geotextile and the aerated bearing layer to protect the geotextile from being worn.

Biochar consists of organic material that is heated in an oxygen-free process, also called pyrolysis.

Stormwater is surface runoff of rain and snowmelt.

The drip line is the imaginary line on the ground around a tree that describes the outer boundary of the tree crown.

Geotextile separates the plant bed from the pavement surface and prevents small particles from being transported down into the aerated layer below and closes the cavities.

Geomembrane seals and protects against water ingress and can be made of various materials such as plastic, rubber or bentonite clay.

Macadam means stones of even size

Biochar macadam is a blend of macadam, nutrient-enriched biochar and compost.

Particle size distribution is the percentage distribution of the size of mineral particles in a given soil or in rock material, and is often reported in a particle distribution curve, also called sieve curve, after soil test analysis.

An aerated bearing layer guarantees that plant bed gas exchange functions properly.

The aeration well allows oxygen and water to the roots and releases carbon dioxide from the soil. When the well fills with storm water, the water flows into the aerated bearing layer and is distributed into the structural soil. At the same time, the water displaces accumulated carbon dioxide from the aerated bearing layer and leaves room for oxygen.

Hardwood chipped wood used as ground cover around trees to keep moisture and keep weeds away.

Pumice stone is an airy material with good water-holding capacity, which is used in plant substrates and together with stone flour as a wear layer.

Pipeline roots are very coarse roots, which are the main source of water and nutrition (see picture on page 7). Damage to pipeline roots can cause trees to die.

Root neck of a tree is placed at the same ground level as the nursery. Adjust the height if necessary with macadam in the bottom of the tree pit (see picture on page 17).

The root zone is the area where the tree's roots grow or are expected to grow.

"Samkross" is unsorted crushed rock with a fine fraction, which is often used in road construction. Samkross should not be used in plant beds as the fine fraction causes the material to be packed too densely.

Structural soil gives plant beds sufficient pore volume and prevents the plant bed from being compacted.

Stone flour consists of crushed rock with fractional limits of 0-8 mm, commonly occurring fractions are 0/2, 0/4 and 0/8 mm. Stone flour is part of the broader concept of co-crush (samkross), which also occurs in coarser fractions.

The structure of the soil describes how its particles (organic and inorganic material) are arranged.

Location improvement shows how the conditions of the tree can be improved underground, ie access to air, water and space.

A strip of macadam without a zero fraction is applied to vegetation surfaces adjacent to hardened surfaces so that storm water is led into the plant bed.

The texture of the soil is the fraction distribution of its inorganic particles, that is, how much rough and fine material the soil contains.

Plant bed means the entire volume of the landscaped planting area. Plant beds can be constructed using various methods such as structural soil and biochar-macadam or specially adapted for example marsh plants.

Plant substrate is a designation for materials that are part of a plant bed.

Superstructure is usually the part of the ground construction that is applied to the surface. In this context, however, it means the part that is applied to the top of the plant bed.

The existing trees on the right have been given new plant beds – Birger Jarlsgatan.

1. Urban plant beds

In the city, buildings, green structure and open water create great variations for the tree's habitat. Air and soil moisture are often low and many surfaces are hardened which gives uneven water access. Groundwater is an important resource that can be used for irrigating trees and other plants. Furthermore, by delaying stormwater in plant beds, the load on the piping system is reduced.

Common problems for city trees

Cities cause a number of problems that inhibit the growth of trees. There is great variation in water supply between different locations and throughout the season. There may be a shortage of water, but when sudden floods occur, all stormwater is diverted to the storm drain system. A layered soil profile also adversely affects the supply of water.

Hard, impervious surfaces and compact soils lead to oxygen deficiency, which causes the roots to die of carbon dioxide poisoning. Oxygen deficiency sometimes occurs when excess water is not discharged due to poor drainage of the soil.

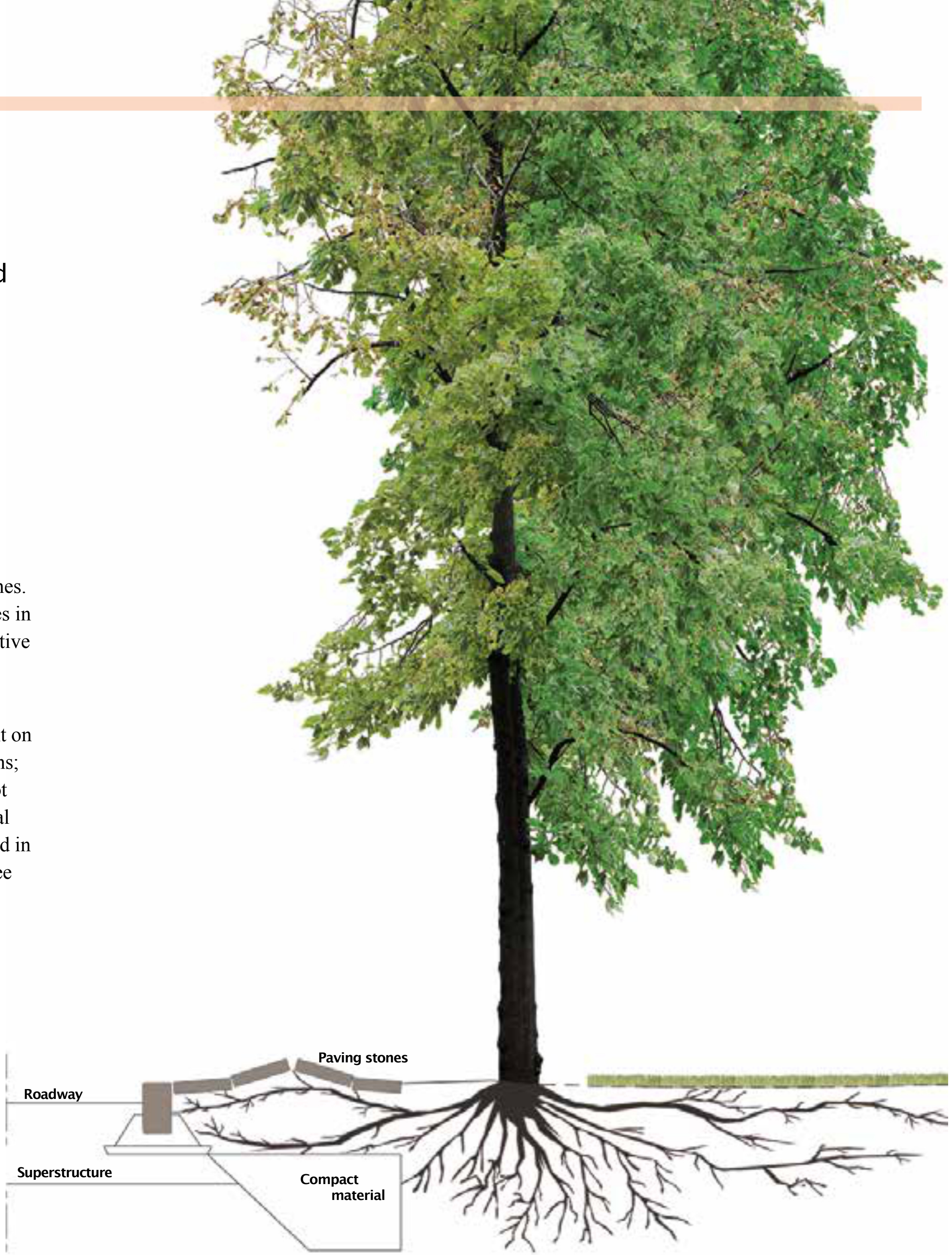
When many functions need to be accommodated in the street space, plant bed volumes often become too small for the root systems. This causes poor tree development and damage to ground cover from roots in search of water.

Excavations and loads within the root zone through traffic and circulation cause physical damage to the roots. Collision and incorrect pruning cause damage to the trunk and branches. Salt damage can occur if road salt accumulates in the plant bed. Clay soils are particularly sensitive as they are compacted by salt.

Root distribution

The root distribution of trees is very dependent on location. Roots grow toward the best conditions; space and good oxygen and water supply. Root systems of city trees differ from trees in natural environments where roots are generally located in the top soil layer. Under hardened surfaces, tree roots search for oxygen and water in conduits, under ground cover, and deeper into the soil.


Damage to city surfaces caused by roots.



A compact plant bed with limited volume makes the tree develop poorly and can cause problems with roots that lift the soil cover.

Since the ground conditions in the city vary greatly, most of the roots of a city tree can be found far outside the drip line of the tree canopy or have an extremely one-sided distribution. The trees can develop rough roots, so-called "pipelines", which account for the main part of the tree's supply of water and nutrition.

Space for roots and conduits

The trees' need for space under ground can affect technical installations. The roots of the trees seek to enter the loose gravel around pipes and cables because of good plant conditions there and often cause blockages in drainage pipes. It is also common for existing trees to be seriously damaged during excavation work for the construction or maintenance of underground conduits, particularly due to leaks from gas lines. This makes tree placement in relation to underground conduits an important aspect of urban planning.

Common problems

- The plant bed has too little volume
- Dense soil cover or compacted soil leads to lack of oxygen in the roots
- Dense soil cover and compacted soil lead to water shortages
- Salt damage and compaction of soils
- Physical damage to root system, stem or coarse branches during construction work leading to root and fungal infestation
- Competition for space below ground between roots and conduits
- Leaking gas lines


The trees in the road median were planted at the same time as the trees in parkland to the right in the picture.


City trees with poor growth – Odengatan.


Pipeline roots exposed during excavation.


Pavement leaves no space for the tree trunk.


Roots and cables compete for space underground.


Excavation damage

Stockholm model

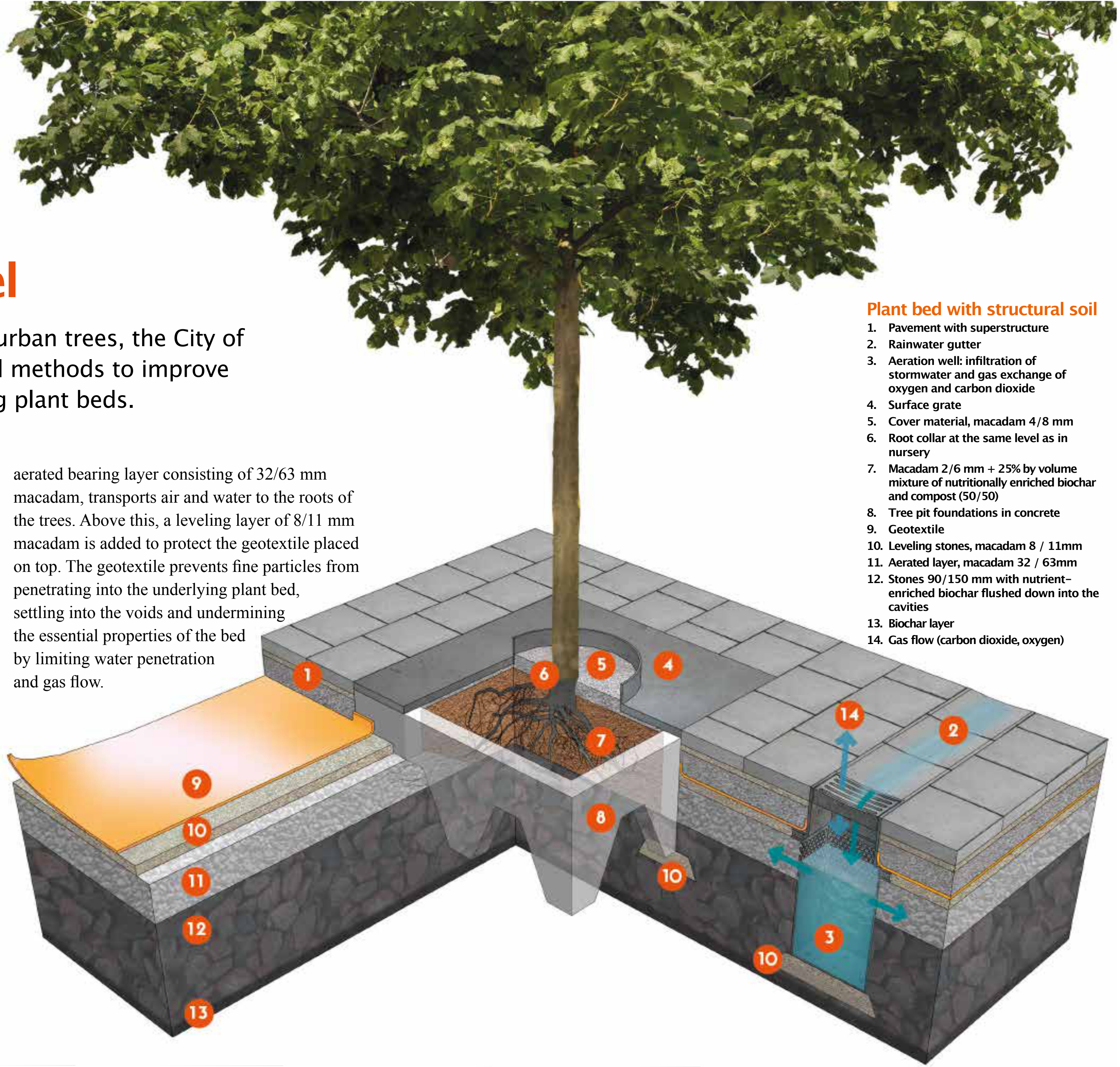
To solve the problems affecting urban trees, the City of Stockholm has developed several methods to improve both new plant beds and existing plant beds.

Structural soil

This method is well established and evaluated in Stockholm. Cavities in the plant bed allow gas exchange for tree roots, and a stable structure with load bearing capacity which prevents the plant bed from being compacted. Structural soil has been tested by the National Roads and Transport Research Institute (VTI) and has been found to have such good load bearing capacity that it can be used under hardened surfaces for roadways and parking areas.

Structural soil consists of 90/150 mm stones with plant soil or biochar in the voids between them. In order for the plant bed to have the desired properties, it is important that the stones are laid out and packed in layers. The soil or biochar is added on top after a stone layer is compacted and flushed into the cavities with a strong jet of water. For this to work, the soil must have a low content of clay and organic material (see Appendix: Grain distribution curve for plant soil type B).

The terrace area in the plant bed is covered with a thin layer of unprocessed biochar. This layer is intended as a filter to purify stormwater. If the plant bed is located under a hardened surface, aeration wells are placed which, together with an aerated bearing layer consisting of 32/63 mm macadam, transports air and water to the roots of the trees. Above this, a leveling layer of 8/11 mm macadam is added to protect the geotextile placed on top. The geotextile prevents fine particles from penetrating into the underlying plant bed, settling into the voids and undermining the essential properties of the bed by limiting water penetration and gas flow.



Plant bed with structural soil

1. Pavement with superstructure
2. Rainwater gutter
3. Aeration well: infiltration of stormwater and gas exchange of oxygen and carbon dioxide
4. Surface grate
5. Cover material, macadam 4/8 mm
6. Root collar at the same level as in nursery
7. Macadam 2/6 mm + 25% by volume mixture of nutritionally enriched biochar and compost (50/50)
8. Tree pit foundations in concrete
9. Geotextile
10. Leveling stones, macadam 8 / 11mm
11. Aerated layer, macadam 32 / 63mm
12. Stones 90/150 mm with nutrient-enriched biochar flushed down into the cavities
13. Biochar layer
14. Gas flow (carbon dioxide, oxygen)

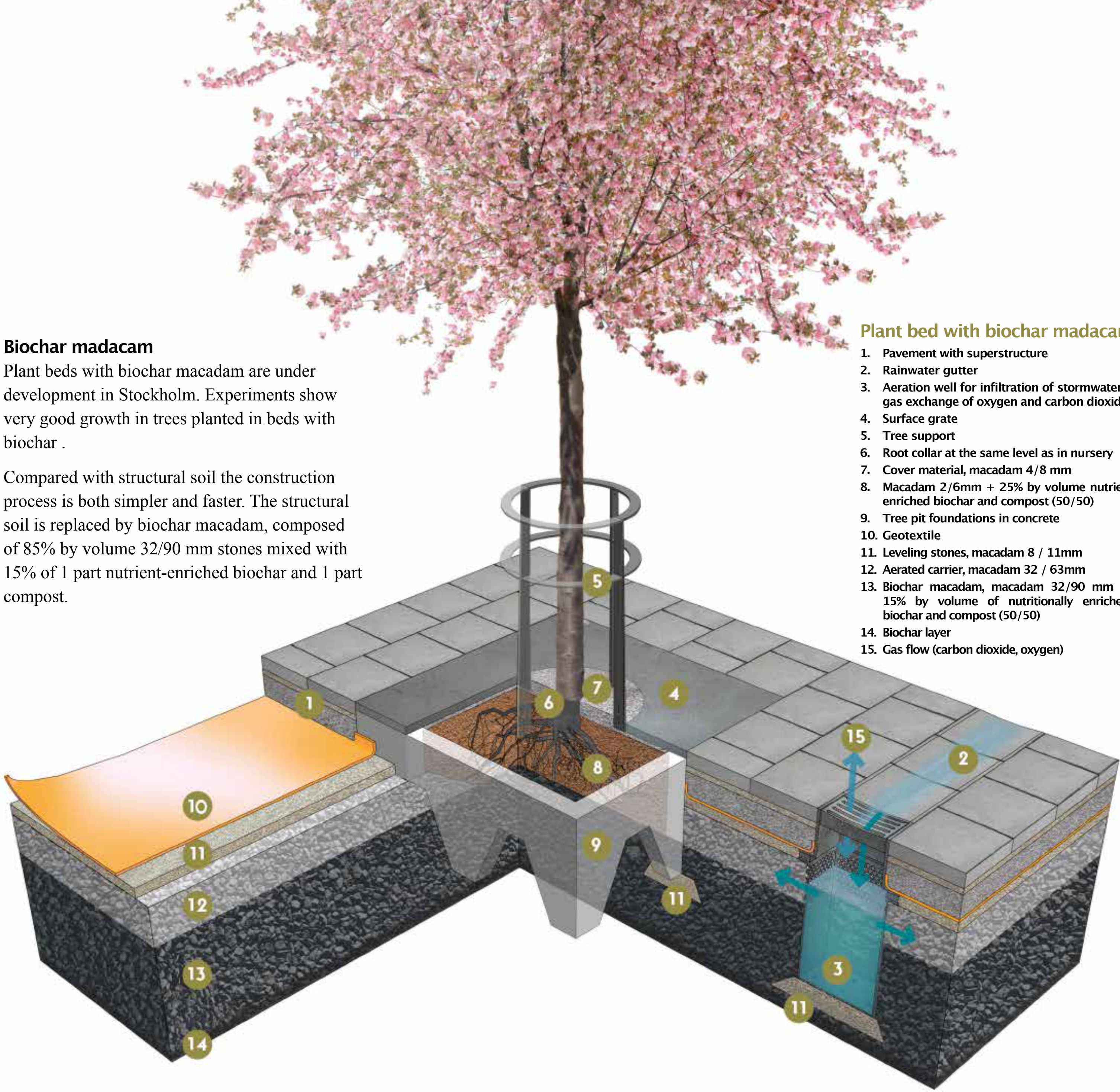
Cherry trees (Prunusavium) planted in a mixture of plant soil and charcoal (50/50), the 2nd growing season – Herrhagsvägen.

Ginkgo (Gingko biloba) in plant bed with structural soil – Hornsatan.

Biochar madacam

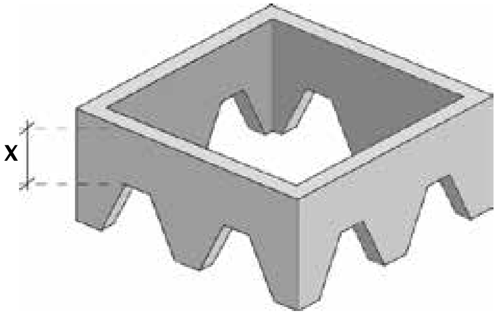
Plant beds with biochar macadam are under development in Stockholm. Experiments show very good growth in trees planted in beds with biochar .

Compared with structural soil the construction process is both simpler and faster. The structural soil is replaced by biochar macadam, composed of 85% by volume 32/90 mm stones mixed with 15% of 1 part nutrient-enriched biochar and 1 part compost.



Plant bed with biochar madacam

1. Pavement with superstructure
2. Rainwater gutter
3. Aeration well for infiltration of stormwater and gas exchange of oxygen and carbon dioxide
4. Surface grate
5. Tree support
6. Root collar at the same level as in nursery
7. Cover material, macadam 4/8 mm
8. Macadam 2/6mm + 25% by volume nutrient enriched biochar and compost (50/50)
9. Tree pit foundations in concrete
10. Geotextile
11. Leveling stones, macadam 8 / 11mm
12. Aerated carrier, macadam 32 / 63mm
13. Biochar macadam, macadam 32/90 mm + 15% by volume of nutritionally enriched biochar and compost (50/50)
14. Biochar layer
15. Gas flow (carbon dioxide, oxygen)



The upper part of the tree pit foundation (height dimension x) must be adapted to the thickness of the pavement superstructure to prevent fines from the superstructure from falling into the tree pit and mixing with the plant substrate.

Stones that fall into the foundation openings mean that the foundation is fixed.

Keep in mind that... distinguish between weight percent and volume percent when calculating quantities.

Tree pit foundations and equipment

Tree pit foundations can be prefabricated or built using granite edge supports or concrete pillars as a frame around the tree's root ball. The tree pit foundation gives space to the root ball when planting, and stabilizes and separates the superstructure of the ground cover and its fine particles from the plant bed. The foundation is filled with plant substrates and can be covered with a surface grate or macadam. Surface grates should be made of durable material such as iron or corten. The type of foundation and associated equipment (grate and trunk protection) is chosen based on the project's conditions. Special solutions, where several sections are built together into larger boxes, must be designed so that they can withstand traffic, for example. It is important that the top of the tree pit foundation is high enough to keep fine particles from infiltrating the plant bed, while allowing the tree roots to reach the surrounding plant bed. The tree pit foundation is placed on structural soil and biochar macadam to level it, respectively, and subsequent macadam layers are allowed to fall into the openings of the foundation to prevent it from sinking.

Ventilation well and support strip

The plant bed must be designed with drainage and good infiltration capacity. With hardened surfaces, aeration wells are placed at low points to direct the water to the plant bed and create an exchange of oxygen and carbon dioxide for the tree roots. The aeration well should be perforated at the same height as the aerated bearing layer, and have holes in the bottom. A well with a volume of 60 liters is placed per tree. To optimize water intake, wells with side inlets can be used in curbs against the roadway. For vegetation areas next to hardened surfaces, a support strip of macadam is applied so that storm water is led into the plant bed.

Stormwater retention

Several technologies are being developed and evaluated to design project-specific solutions for stormwater retention and irrigation of the trees.

However, several basic conditions are common:

- good infiltration capacity of the plant bed
- good drainage and lateral flow that prevents standing water
- plant bed volume can handle expected amount of stormwater
- reasonable level of operation and maintenance

DRAWING THVB022

Existing soil

Parks and natural environments with naturally formed soil are a resource that should be handled with care so that the soil is not compacted. There are several advantages to using existing soil with undisturbed structure for plant beds that are planted in an existing park or natural environment.

Utilizing existing soil that has been excavated and stored is the next best option. However, there is a risk that its microbiological life will be damaged and the aggregate structure destroyed.

Soil improvement of existing or reclaimed land reduces transport and resource consumption. Manufactured plant soil appears to require more extensive fertilization over time, and may lack the microbiology that fosters good soil properties.

Well cover with side entrance.

Rainwater drain with aeration well connected to plant bed.

Perennial planting under trees performed in connection with plant bed renovation after two growing seasons – Norr Mälarstrand.

Perennials in plant bed with biochar madacam at planting and after a growing season.

PPerennials and trees in plant bed with biochar madacam – Råcksta. Photo Hildegun Varhelyi.

Perennials in plant bed with biochar macadam at planting and after two growing seasons – Pilgatan.

Soil analysis and soil improvement

Soil analysis should always be performed before plant soil is applied to the plant bed, whether it is manufactured or existing soil. The sample is analyzed in the laboratory and should result in a grain distribution curve, mole content, pH value and nutritional status according to the AL method. The soil in the plant bed should be homogeneous throughout the profile, without separating packed layers or layers of material with other grain size distributions.

Soil improvement is carried out on the basis of soil test analysis and taking into account the requirements of the planted plants. When planting trees and shrubs, the humus content in the top 400 mm of the plant bed should correspond to 5-8% by weight. Perennial plantings can have a higher humus content, while grass areas can withstand a humus content of less than 2% by weight. Below 400 mm depth, the humus content should always be less than 2% by weight.

When compost or similar organic material is used to increase the humus content, there is a risk that the nutrient and water-holding capacity will decline unless new organic material is continuously added. If nutrient-enriched biochar is added instead of compost, the nutrient and water retention properties of the soil will endure for a much longer period of time.

If existing soil is only improved before planting, any construction work must be planned so that the area is blocked off. Any machines that can compact the ground should not be allowed in the area.

Biochar

Biochar consists of organic material heated in an oxygen-free process called pyrolysis. Biochar binds carbon from the atmosphere, reduces nutrient leaching and binds heavy metals. Biochar, unlike charcoal, contains moisture, which makes it easier to handle. Biochar used by the City of Stockholm must be certified according to the European Biochar Certificate (EBC) or have equivalent properties.

The purpose of using biochar is to create long-lasting plant beds, which are made up of materials that can be produced locally.

Biochar can also be mixed with plant soil to improve soil structure and provide better water and nutrient retention capacity. The advantage, compared to peat moss or compost which have similar properties, is that biochar decomposes more slowly.

Biochar alone, depending on the feedstock used to produce it, can have a low level of available minerals. Hence the plant bed should be fertilized with mineral or organic fertilizer.

Biochar.
Photo Kari Kohvakka for Stockholm Water and Waste.

Japanese cherry (Prunus'Umineko ') in plant beds with structural soil – Kocksgatan.

Metasequoia (Metasequoia glyptostroboides) in plant beds with structural soil – Grindsgatan.

Lind (Tilia x vulgaris 'Pallida') in plant beds with structural soil – Odengatan.

Plant soil and plant substrates

To flush soil in into the base macadam layer, manufactured soil type B is used. It should be tested to have a grain distribution curve that fits within the green field in Appendix: *Grain distribution curve for plant soil type B*. The plant soil shall meet the general requirements for nutritional status 13 Table RA DCL.23 / 1. In order for the soil to be flushed down easily, the humus content should be less than 2% by weight and the clay content 4-8% by weight.

Around the root ball, a plant substrate is used that meets the newly planted tree's need for air and moisture containing material. This applies to plant beds in hardened areas as well as in parkland and whether it is structural soil or biochar macadam. This substrate may consist of a mixture of macadam 2/6 mm and 15 to 25% by volume mixture of nutritionally enriched biochar and compost, alternatively pumice and compost. A lower concentration of biochar and compost provide a drier and leaner substrate, while a higher concentration creates a more humid and nutrient dense substrate. The above also applies to perennials and bushes, where alternatively 4/8 mm macadam can be used in the mixture. For grass areas, the above plant substrates are also recommended, but for higher stability, 2/8mm macadam can be used in the mixture.

The compost should be mature and the biochar nutritionally enriched with hygienic organic fertilizer or mineral fertilizer NPK 5-1-4 with micronutrients.

Tree plant beds in parkland

If the soil profile is disturbed - for example, due to compaction, soil remediation or replenishment - the plant bed must be sized with the same volume as for a street tree, ie at least 15 cubic meters. If the roots of the newly planted tree can eventually spread into a larger vegetation area with a natural profile, the planting bed at planting may be smaller.

DRAWING THVB025

Plant beds for grass, shrubs and perennials

The structure of plant beds for bushes and perennials should be adapted to the needs of the plants in terms of nutritional content, pH and water supply. It is important to take ongoing maintenance into account. Plants that require irrigation after establishment should be avoided. Also take into account the expected level of weeding and the need for pruning, for example.

For grass surfaces, the function, expected wear and planned maintenance level must be taken into account. An ornamental lawn that must be mowed frequently, a utility lawn with high wear or a dry meadow with a very low maintenance level places different demands on the plant bed. Adapt the plant bed design accordingly.

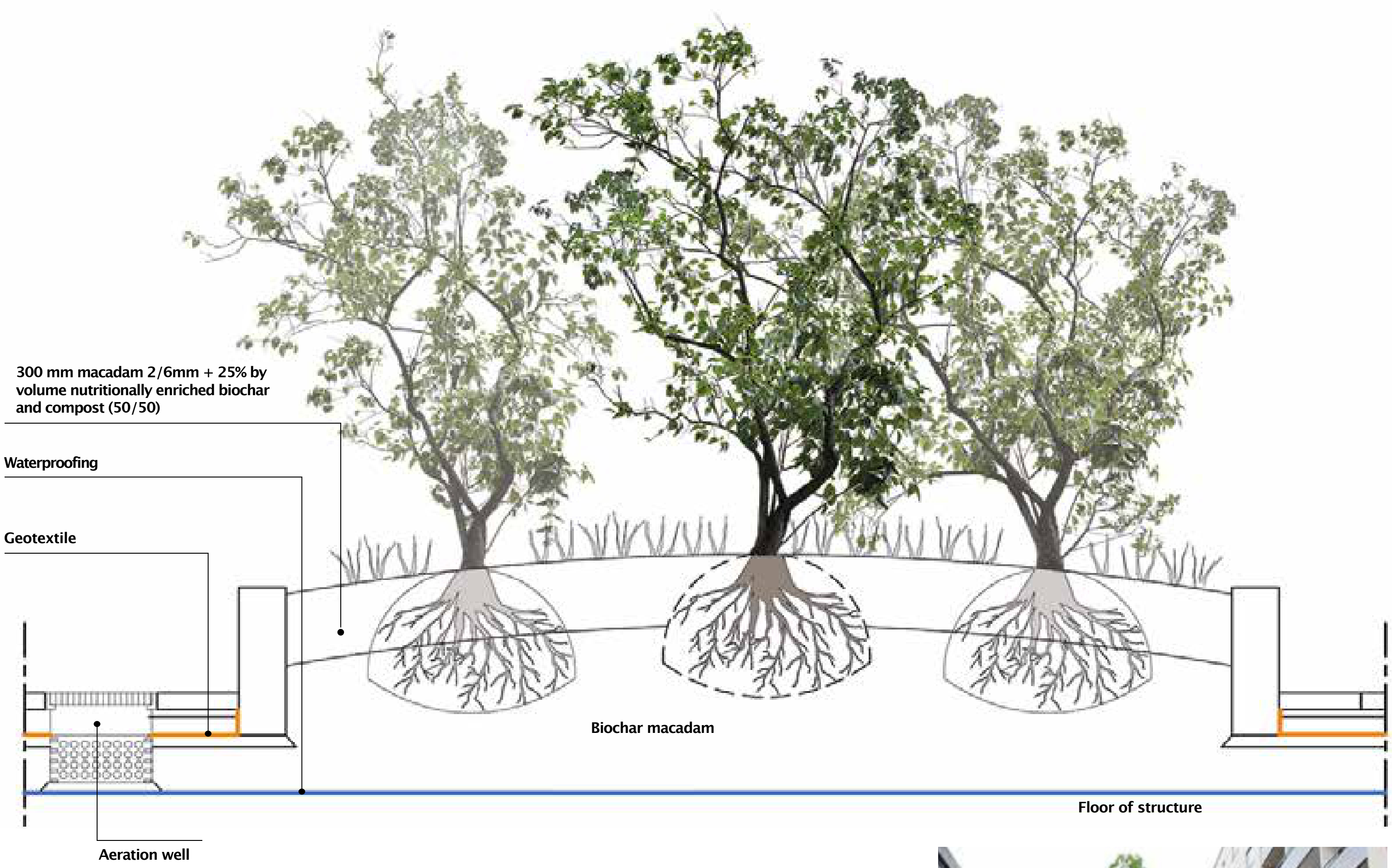
DRAWING THVB025

Trees on a structure

In the city, a structure often exists under squares and streets to support the roof over a garage or subway, for example. The prerequisites for planning and designing plant beds on such structures are project-specific. The goals of the plant design, the plant beds and the floor/roof structure are adapted to each other. Therefore, no specific solutions are provided in this manual. Detailed solutions are described in the "Greenery handbook" (Pettersson Skog, A. et al. 2017.) which is available online - www.gronatakhandboken.se.

In most cases, a plant substrate with mixed lightweight materials, in combination with plant soil, is required to provide sufficient pore volume and reduce the load on the structure. Recommended substrate depths, that is, plant bed depths, for different types of vegetation are described in Table 5 in the "Vegetable roof guide" (Petterson Skog, A. et al. 2017.).

For small trees and shrubs, the minimum substrate height is 600 mm. For larger trees, heights above 1000 mm are required. The depth of the plant bed in combination with the pore volume of the substrate controls the balance of vegetation's access to oxygen, water and nutrition. Shallow plant beds require a relatively high proportion of pore volume for excess water to drain away.



In street environments where there is limited space to make raised plant beds with aerated bearing layer under the surrounding ground cover (see above). Groundwater is supplied via several shallow aeration wells. The image above is an illustration of a possible situation and does not describe a technical solution.

In a coarse gravel or sandy soil, water and nutrient retention capacity is limited. Without continuous irrigation and nutrient supply, only plants adapted to drought and nutrient poor environments can survive. By incorporating pumice stone or biochar into coarser stone fractions, a high pore volume and a relatively high water holding capacity are achieved. The properties of these materials allow the soil to supply the plants with water and be well drained with good oxygenation. However, it is important to take into account the extra weight of the water on the structure underneath.

Raised plant bed – Hornstull.

Planning considerations

Planning

The location of trees should be planned as early as possible. During the detailed planning phase, trees must be given space in the street section, both below and above ground. Coordination with wiring, parking and access, lighting, balconies, public transport and more must be carried out. Consideration should also be given to how the height of the street can create opportunities to utilize the storm water as a resource for irrigating the trees. This is important for good design and a reasonable level of maintenance. The possibility of preserving existing vegetation must be weighed against whether it is feasible at the planting stage. Such an assessment can only be made after the tree's crown and root zone have been examined. Tree migration methods are not covered in this manual.

Design

During the design phase, coordination from the planning phase continues at a more detailed level. As the technical description is superior to the drawings in the contract documents, it is important that these are delivered together for review and that they are consistent.

The plant bed must be large enough - the volume of the structural soil should be at least 15 m3 per tree - and the entire plant bed must be coherent. The elevation and disposition of the soil must allow water to be directed to the plant bed. In hardened surfaces, one aeration well is placed per tree where they will collect water, for example in creases in the pavement or in gutter valleys. The plant bed must be designed in a conscious way with drainage and good infiltration capacity. It is important to access where water will flow. If the structural soil becomes water-logged, the excess water must be able to flow into the ordinary stormwater system. In the case of a sloping terrace, a dam should be installed to prevent water from being transported away from the plant bed too quickly.

The aeration well is placed at sufficient distance from the tree that damage from roots entering the well is avoided.

During construction, air supply to the plant bed must be secured to prevent oxygen deficiency from damaging the plant bed during the period leading up to the completion of aeration wells, the superstructure and planting.

CHOICE OF TREE SPECIES

Adapt the species choices to the conditions provided by the site, such as space in the street space, water supply and lighting conditions. Newly planted trees in a public setting should maintain a certain size and trunk height to prevent vandalism, and allow traffic to pass them. Generally, a girth of at least 30-35 cm is recommended, which is measured 1 m above the ground. The trunk height should be between 180-220 cm. Over time, the vast majority of street trees are trimmed up to 450 cm trunk height for traffic to pass under the crowns.

ROOT BALL

The root ball of a tree with a girth of 30-35 cm is about 100 cm in diameter and about 60 cm deep. The root ball must fit inside the tree pit foundation - a standard 140x140 cm foundation has an inner dimension of 120x120 cm. It is good to have about 10 cm margin on all sides as the root canal is very irregular. To avoid planting the tree too deeply, the root neck should be illustrated so that it is level with the finished ground surface on the drawing.

The root ball on a tree with a stem girth of 60–70 cm.

A narrow crowned tree is suitable near a facade. Photo Lovisa Hell.

The geotextile dam in aerated bearing layer.

Not all trees can be saved during new construction. This tree has no chance of survival.

Be aware that some design choices may place the root neck too deep. If this is the case, choose another solution.

GEOTEXTILE

The geotextile should prevent fine particles of sand and silt from infiltrating the aerated bearing layer. The leveling layer prevents the geotextile from being worn against the aerated bearing layer. Therefore, the geotextile is placed on top of the leveling layer and is folded up against the edge of tree pit foundations, aeration wells, etc. The drawing should clearly indicate where the geotextile is to be located. The most common drawing error is that the geotextile is not clearly marked, or is shown with such a thin line that the drawing becomes difficult to interpret.

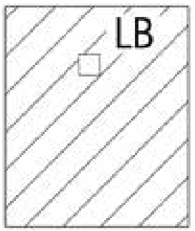
When planting beds are placed directly adjacent to existing power cables, they can be protected with geotextile. Use class N2 or N3 (see Principle section on page 16).

For plant beds near facades, a 0.5 mm thick LDPE geo-membrane is laid against the excavation edge on the facade side.

CURBS

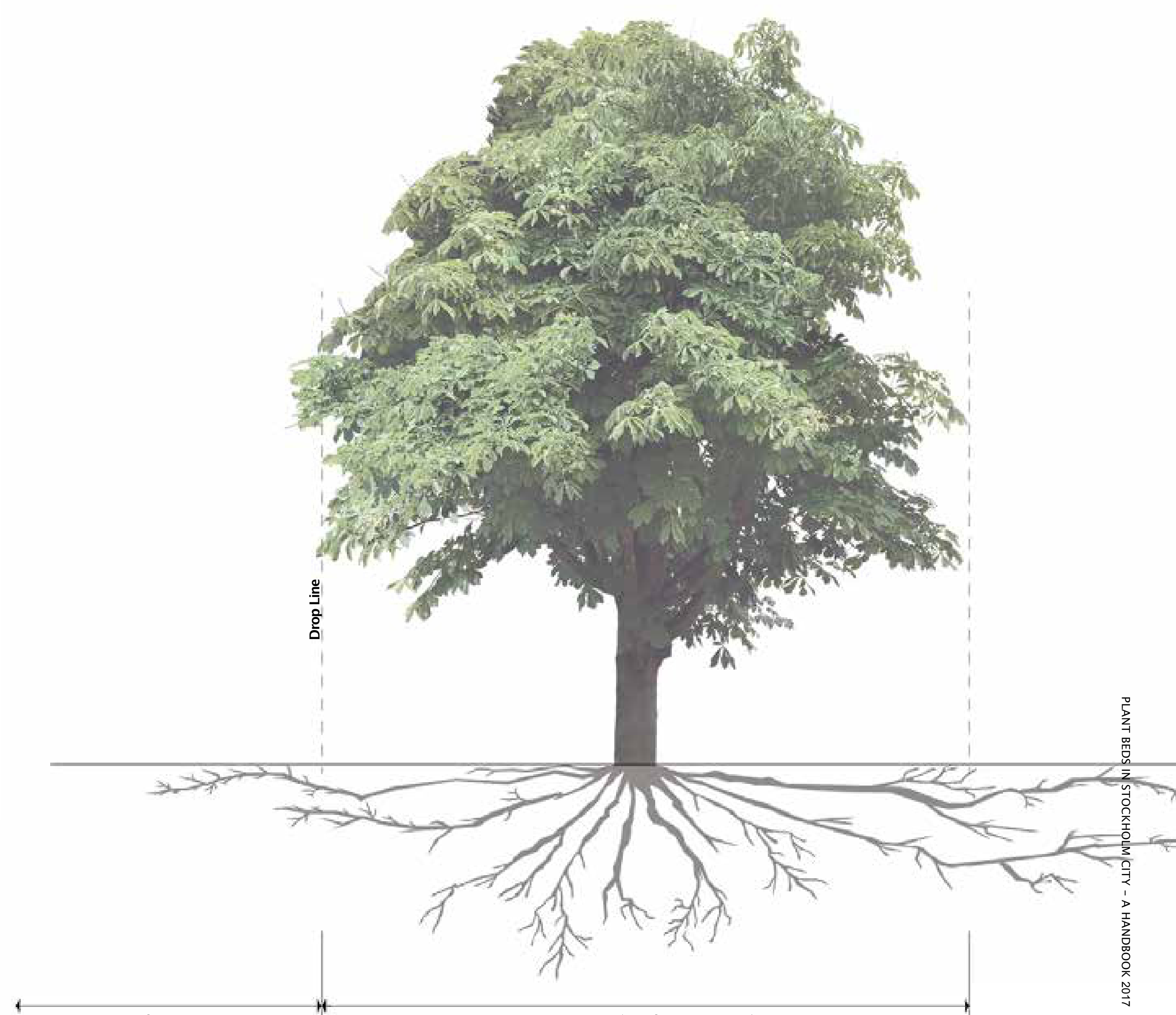
Curbs that cut through a plant bed must not create interruptions - all layers of the plant bed must be continuous.

AMA BJB.29



MEASURES FOR EXISTING TREES

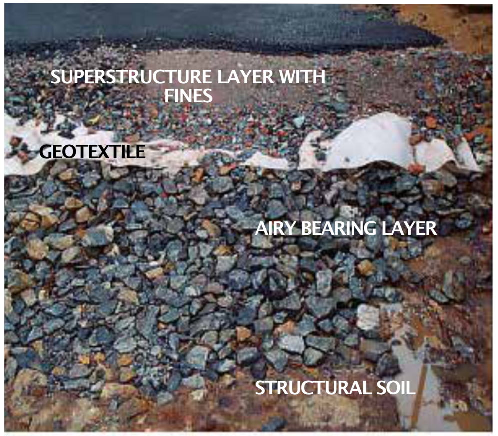
If work is done within the root zone of existing trees, the roots must be taken care of and placement within the root zone should be avoided. If the root zone is still affected, careful excavation and restoration is prescribed with a suitable plant bed. See more in Chapter 2.



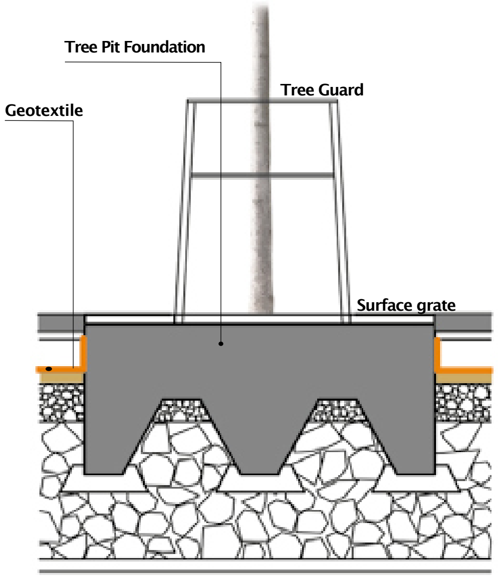
In natural environments, tree root systems are often shallow and wide as roots search for the upper soil layer with access to oxygen and nutrients. However, this varies widely depending on tree species and soil conditions. In urban hardened areas, the conditions and thus the root distribution are often completely different, which is why sample excavation is crucial before general excavation within the root zone begins. The tree root zone generally extends 2.5m horizontally beyond the tree canopy (the drop zone).

Principles of structural soil

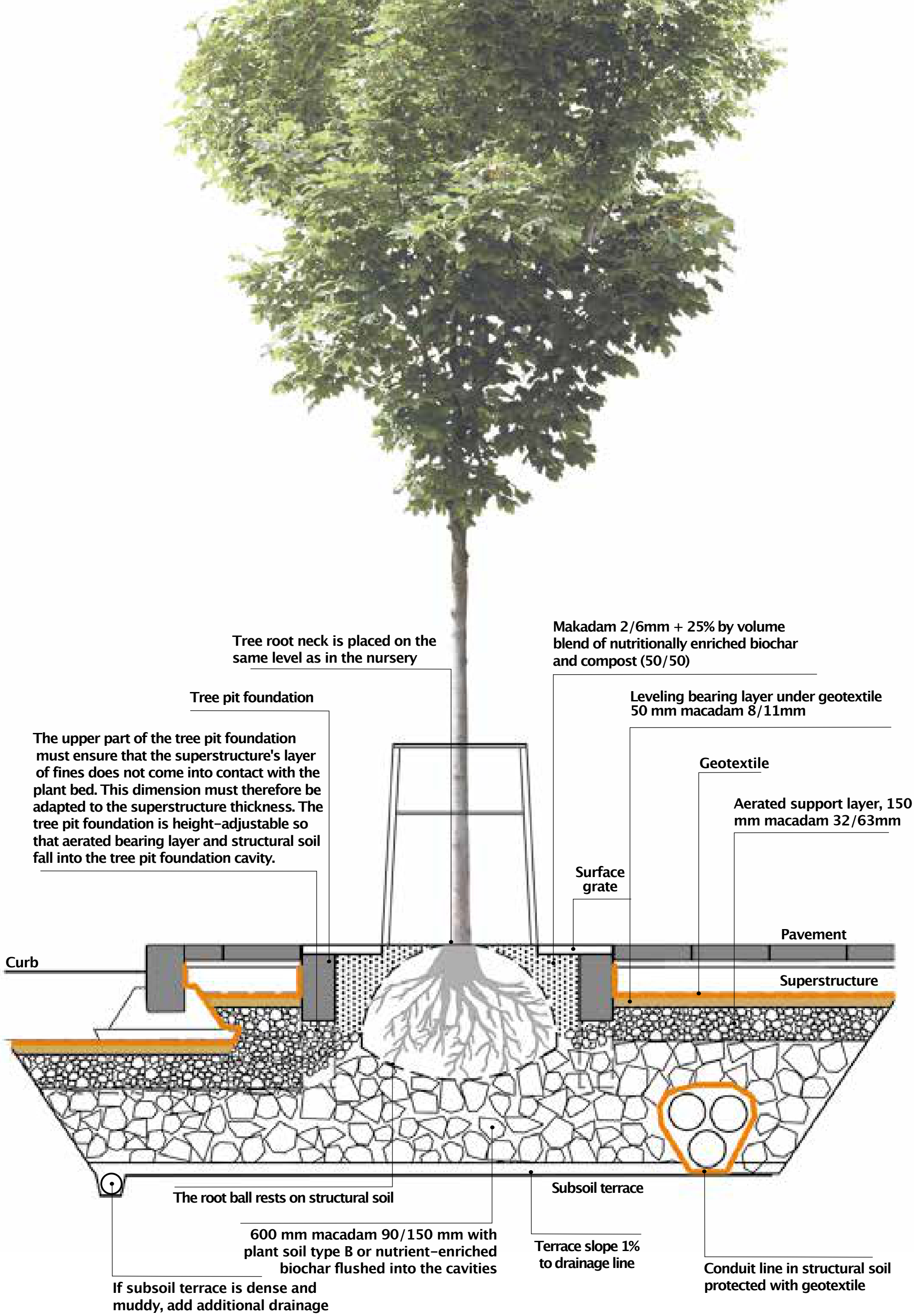
Newly planted trees with structural soil after about eight growing seasons – Erik Dahlbergsallén.



Layers of a plant bed with structural soil.



Principles of structural soil



Considerations when planting

Initial work and documentation

At excavation, the nature of the subsoil terrace should be determined. The terrace may prove difficult or inappropriate to loosen in the manner prescribed by the documents. Dense terrace surfaces must be drained and overly permeable terraces must be sealed - for example with the help of clay.

Complete documentation of the execution of construction work is crucial to the result. The control plan is described in more detail on page 24.

Planting

In order to have enough cavities for the roots of the trees but still maintain a stable construction, the rocks in a structural soil should be of even size, usually between 90 and 150 mm. It is important to check that all the fractions used in the planting bed are in accordance with what is prescribed.

A serious mistake is the use of fines (with zero fraction). Fines are common in road construction, but in plant beds it does not work because the zero fraction causes the material to be packed too hard.

Pre-mixed structural soil must also not be used. When transporting pre-mixed structural soil, the properties of the material change. The plant bed becomes too dense when compacted. This type of structural soil also does not have the bearing capacity required, as there is a risk of it settling in future. However, pre-mixed biochar macadam and structural pumice are not affected in the same way by transport and therefore can be used.

FLUSHING SOIL INTO STRUCTURAL LAYER

Flushing soil down into the structural layer is time consuming. To optimize the process, the soil should be laid out in very thin 2cm layers and washed down with a hard jet. If the soil layers are too thick, it becomes difficult to flush the soil into the cavities.

TREE PIT FOUDATIONS / AERATION WELLS

Tree pit foundations and aeration wells are level adjusted with macadam 2/6mm or larger. Finer particles must not be used.

At construction, stones from structural soil and aerated bearing layer should cascade into the side openings of the tree pit foundation at a consistent descending angle. Any attempt to prevent the stone from rolling into the box, by wrapping the box in geotextile for instance, can cause future settling of the surrounding pavement.

The lower edge of the concrete ground slab should be set lower than the top of the tree pit foundation to avoid settling and to prevent roots from entering the sand. Alternatively, the concrete ground slabs are placed in concrete. (See following page for diagram.)

The aeration wells should receive stormwater and therefore be placed at low points. The aerated bearing layer should cover the entire perforated section on the side of the aeration well.

GEOTEXTILE

The most common error in the construction of structural soils is that the geotextile is placed between the wrong layers. The geotextile must prevent the fine particles from the support layer under the pavement from being mixed with the aerated bearing layer. The leveling layer prevents the geotextile from being worn against the aerated bearing layer. Hence, the geotextile is placed on top of the leveling layer. The geotextile is folded up against the edge of tree-pit foundations, aeration wells and edge supports, also to prevent fines from entering the plant bed structure. Therefore, the geotextile should be edge cut only after the support layer under the pavement has been laid out.

PLANTING

Tree planting should normally be carried out during late autumn. It is important that trees are planted immediately after delivery. Tree roots should be placed at the same level as in the nursery.

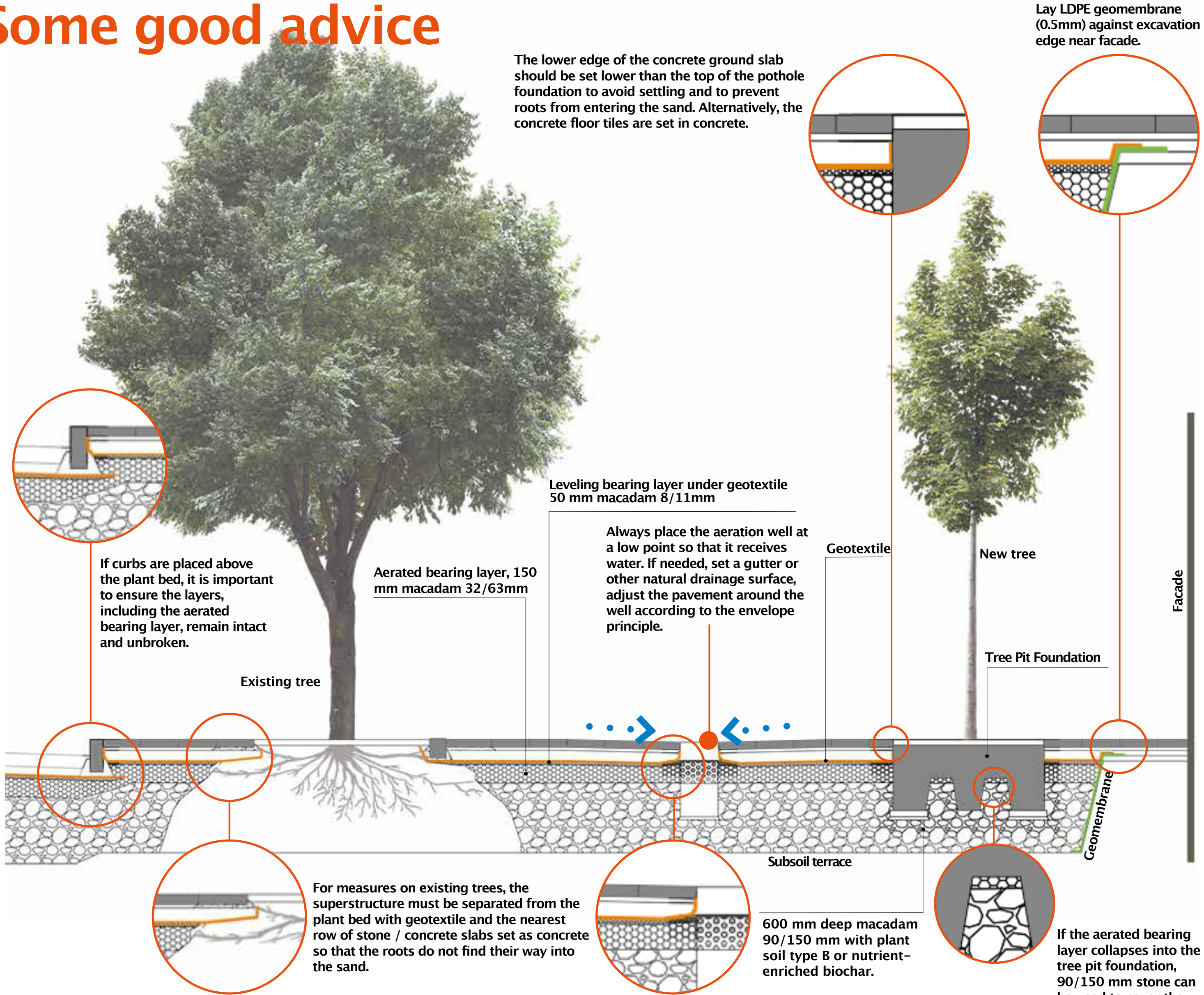
EXISTING VEGETATION AREAS

When beds are planted in existing vegetation areas, compaction damage often occurs through construction traffic and storage. It is also common for existing trees to suffer damage to the crown or trunk. This is sometimes due to ignorance of the contractor and sometimes to insufficient planning of the workspace layout. See Chapter 2 for further guidance.

Geotextile extends across the leveling layer and the entire plant bed. It is important that the geotextile folds against tree–pit foundations, wells and edge supports to prevent the pavement bearing layer from being mixed with aerated bearing layer.

Tree root neck placement at the same level as in the nursery. The height position is adjusted as needed with macadam in the bottom of the tree pit. Photo Lovisa Hell.

Some good advice



Execution of the respective plant beds is reported in detail in Appendix: Execution descriptions.

Common errors

- Wrong fraction is used, particularly containing fines in the mix
- Pre-mixed structural soil is used
- Adaptation to the nature of the subsoil terrace has not been made
- Soil is added in thick layers when it is to be flushed down into the structural layer
- Aeration wells are not placed at low points
- Geotextile is placed between the wrong layers
- Macadam is prevented from falling into the tree pit foundation with slabs or geotextile
- Trees are placed at the wrong level

Incorrect design: boards have been set to prevent the structural soil from falling into the foundation. When the boards in the future collapse, the ground around the box will settle.

2. Solutions for existing trees

There are many reasons to carry out work within the root zone of existing trees – new hardened surfaces, new buildings or maintenance repairs are some examples. Sometimes work in the root zone are performed simply to give the trees better conditions. In order to reduce the impact on the trees, special procedures must be followed.

Planning and evaluation of actions

When working on a site with existing trees, an assessment of the value and condition of the trees should be carried out early in the planning stage to determine if the project design should be adapted to the trees' situation. Such investigations should be carried out at the detailed planning stage.

The type of action is of great importance for whether a tree can be saved or not. For example, the foundation of a building with deep excavation requires greater distance from trees than pipe laying. Therefore, the feasibility of planned measures must be assessed.

The tree inventory should be carried out in a professional manner by, for example, an arborist. It includes a visual examination of trunk injuries, previous pruning injuries, age assessment, signs of illness and vitality. A systematic assessment of the tree's conservation value is then made from several skilled perspectives.

Test excavation and root mapping are performed to find out the distribution and condition of the roots, as well as the exact location of existing cables and pipes. The project conditions determine the extent to which the excavation is performed. The excavation is documented with pictures and protocols (see checklist p. 22).

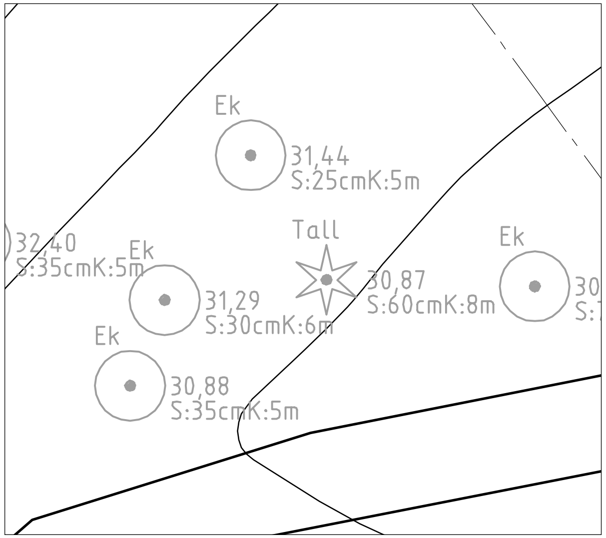
Different species of trees are sensitive to excavations, pruning of large roots and other work within the root zone in different ways. Altered conditions of water and light supply can also adversely affect the trees.

Knowledge base

Details that may be helpful in planning and / or construction:

- Property Limits
- Provisions in existing detailed plans
- Existence of existing pipes and cables
- Tree measurements; stem and crown diameter, ground height and the presence of rock and possibly root mapping
- Water table
- Soil texture (fractional distribution) and level of compaction

Sample excavation in structural soil for root distribution evaluation.



Measurement of trees with height, trunk diameter (S), and crown diameter (K).

Tree Inventory. Photo Anders Ohlsson Sjöberg.

Protection of roots, stem and crown

Planning of protective measures

Tree root systems are sensitive to both excavation and compaction. The crown and stem must also be protected during excavation and must not be used to support materials. For example, materials may not, under any conditions, be inclined or anchored to the trunk or branches. Contact with the city's representative for planning protective measures for roots, trunk and crowns must be made well in advance of the work being started.

Before construction work begins, all protective devices must be installed by personnel with knowledge of tree protection both above and below ground. Inspection of tree protective devices is carried out according to the agreed interval by an independent inspector who is not a party to the contract. Fines for damage to trees and violation of safeguard measures shall be included in the contract with the contractor according to the city's template. Any damage must be reported immediately to the responsible inspector for protective measures.

Protection of the root system

In theory, the root zone of the tree encompasses the ground under the tree's crown to 2.5 m outside the outer crown (drip zone), but varies depending on tree species, soil conditions and surface coverage (see illustration on page 15). The most effective way to protect the root zone during construction is to keep a distance by setting up a barrier (see Fig. 1). This is done to prevent vehicles from driving over or parked within the root zone or storage in the root zone. The fence is made with a minimum 2 meter high building fence, which is anchored to the ground, without damaging the roots, so that it is not possible to move. Signs informing that this is a protected zone for trees and which rules apply should be affixed to the fence.

Furthermore, smaller machines should be used for work near existing trees and leveling of soil surfaces must never be carried out using the excavator's bucket. If a vehicle has to cross the root zone, the calculation of the vehicle load shall be the basis for the choice of safeguard measure. An example of a safeguard measure to counteract compaction is geotextile covered with a layer of macadam, leveled with co-crushing 0/32. Alternatively, specially adapted ground protection plates can be used. Upon completion of the work, the ground shall be inspected by an independent inspector. In the event of compaction, a plan for restoration must be drawn up.

Protection of trunk and crown

Tree trunk protection is done with short sections of building fencing with tires mounted on the inside. In exceptional cases, embedding with resilient material closest to the stem may be required. Nails or other fasteners should never be used to attach anything to the trunk.

To avoid damage to the crown caused by cranes, excavator arms, sheds or tall vehicles, pruning can be done before work starts. When excavating near existing trees, it is important that the excavator arm does not enter the tree crowns. Any pruning should be done by the city's designated representative.


No fencing and no protection against soil compaction


No barrier: storage and contracted fence within the root zone.


No cordon around the trees: The setup of this project site allows cars and heavy machinery to repeatedly compact soil in the root zone of these trees, and drive through the crowns as well.


Trees protected with cover and boards for plant bed renovation. Photo Lovisa Hell.


The fence is placed beyond the trees' drip line. No materials may be stored inside the fence. No traffic or machinery may move inside the fence.

Excavation, pruning of roots

When excavation is necessary within the root zone where superficial roots, dense root mats and coarse roots can occur, root damage is minimized by careful digging methods. Hand digging can be used for smaller jobs, but for larger excavations, vacuum and compressed air methods are more efficient. Soil conditions and weather also affect the choice of method, which should be taken into account in both planning and construction.

Excavation damage to the root system can lead to rot later on. Therefore, avoid scraping, tearing or cutting rough roots. If roots need to be pruned, it should be done with a straight cut with saw or pruning shears so that the root can quickly heal and form new roots from the cut. To stimulate new root formation, a planting bed with good conditions is required.

Pipes or cables can be installed by tunneling under the roots by hand, or by using vacuum or compressed air to avoid damaging the roots.

Fine roots are more susceptible to cold and dry damage than the coarser roots. Roots that are exposed during excavation work must therefore always be kept moist and watered. If tree roots are exposed for more than an hour, they should be covered to retain moisture. If work is carried out under strong sunlight, wind or freezing temperatures, exposed roots should be covered within fifteen minutes. Another method of protection is a root drapery, constructed of a coconut mat mounted on wooden stakes to retain moist soil around the roots, which is described in the Technical Manual type drawing TH0002 (see the image upper right).

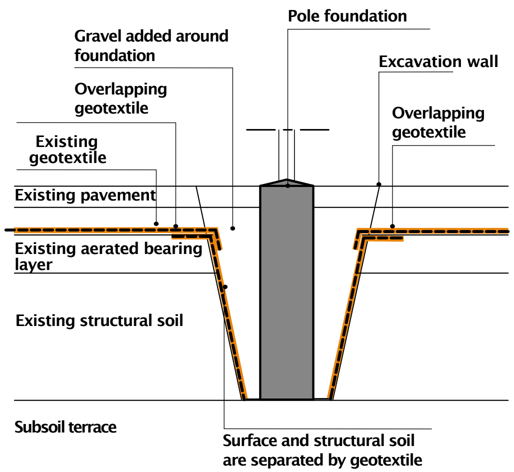
Irrigation should be carried out so that the water infiltrates down between the roots or in the terrace floor. The protective devices are removed before refilling.

AMA BCB.4 och BCB.5 (med underkoder)

DRAWING THVB025

Pruning guidelines

- All tree roots should be cut in consultation with the client.
- Within a 3m radius of the trunk, no roots thicker than 30mm should be cut.
- Beyond a 3m radius from the trunk, roots that are 30–50mm thick can be cut with pruning shears. In exceptional cases, roots thicker than 50mm can be cut with a saw.



Restoration when laying foundation in existing structural soil.

Recovery

Restoration of existing structural soil occurs with workflow corresponding to existing situation. Extracted structural soil should never be dumped back into the plant bed. Instead, layers with different pore sizes are formed. Larger roots are covered with macadam 2/6mm and 25% mixture of 1 part nutrient-enriched biochar and 1 part compost (see also Fig. 4 on page 23). For restoration after setting foundation, see figure above.

Roots cut with pruning shears.

Root drapery of coconut carpet mounted on wooden stakes with moist soil. When backfilling cannot be carried out immediately, the root canopy protects the tree roots from dehydration.

New root formation after proper pruning.

Tunneling of pipe under roots using vacuum excavation.

Irrigation of exposed roots.

Covering of roots with biochar macadam.

Plant bed renovation

Many city trees have developed severely deteriorated root systems over time. After examining and evaluating the trees, a renovation of the plant bed may be preferable to replacement with new trees and plant beds. A renovation helps to extend the tree's life and can consist of:

- installation of an aerated plant bed for trees with poor growth due to compacted soil
- an increase in root space for trees with superficial root system that is lifting pavement
- use of airier material around a tree trunk that has been submerged in the ground

After the necessary studies have been carried out, a proposal for a new plant bed is made. The depth and structure of the plant bed is affected by the spread of the tree's root system, the prevailing problems and the design of the site. The work process for plant bed renovation therefore differs from case to case. Generally, it is implemented in this way:

- With careful excavation, parts of the existing root system are exposed so that it can make contact with the new aerated plant bed. The excavation is sufficient when a large amount of fine roots are exposed. This usually occurs at depths of 500- 600 mm, but sometimes the fine roots are directly below the surface. In other cases, roots are only found at over a meter deep.
- Exposed roots are immediately protected (see "Protecting Roots" on page 20).
- Pruning of roots occurs only in exceptional cases (see "Pruning guidelines" on page 21).
- Where roots are not found, the terrace is closed to a depth of 200 mm.
- The new plant bed is developed. It may consist of structural soil or biochar macadam, or an aerated bearing layer consisting of macadam 32/63 mm or pumice stone 2/8 mm. Larger roots are covered with macadam 2/6 and 15-25% volume mixture of 1 part nutrient-enriched biochar and 1 part compost (see fig. 4 on p. 23).
- Fertilization is carried out with long-acting manure 100 grams / m2 between spread and packed layers.

Linden in poor condition on Kungsbroplan, before plant bed renovation 2002.

Same tree after plant bed renovation 2013.

Analysis for plant bed renovation

Plant bed renovations are expensive. Hence it is important to first determine whether the tree can be improved. A visual assessment. Is there room for a new plant bed and space for the tree as it begins to grow after renovation? Are there any restrictions on how the site may change? Streets and curbs, ground conditions, conduits and other underground installations must therefore be mapped.

A sample excavation obtains important information about the distribution of the roots, soil, and other conditions at the site. If the tree grows in a park environment, three to ten hand-dug pits are sufficient. For hardened environments, one to two pits of about one cubic meter each are selected. The location of test pits depend, among other things, on the size of the tree.

Checklist for sample excavation

- ☐ Vitality and damage
- ☐ Age and growth in recent years (shoot growth).
- ☐ Tree species (species are variously susceptible to root damage).
- ☐ Soil texture / structure (affects the choice of excavation method for subsequent work).
- ☐ Soil volume and plant space (is there room for a new plant bed?)
- ☐ The distribution of the root system

Sample excavation of oak on Fiskartorpsvägen – rotting and dead coarse roots were discovered at 60–70 cm depth.

If the tree is located in a hardened surface, at least an aeration well is set per tree and the plant bed is covered with geotextile before the superstructure of the ground cover is laid out. Solutions where stormwater is distributed with infiltration pipes can also be a good alternative.

DRAWING THVB020 / THVB021 / THVB022

If the tree is in a vegetation area, the stormwater is led to the plant bed from the surroundings via an aerated support strip consisting of macadam 4/8 mm without biochar. The vegetation surface is preferably planted with perennials or shrubs rather than a mown grass area, as the latter takes a greater proportion of nourishment and water from the tree.

DRAWING THVB024

Plant bed renovation on Birger Jarlsgatan.

Vacuum excavation / exposure of root systems on adult trees with compressed air lance.

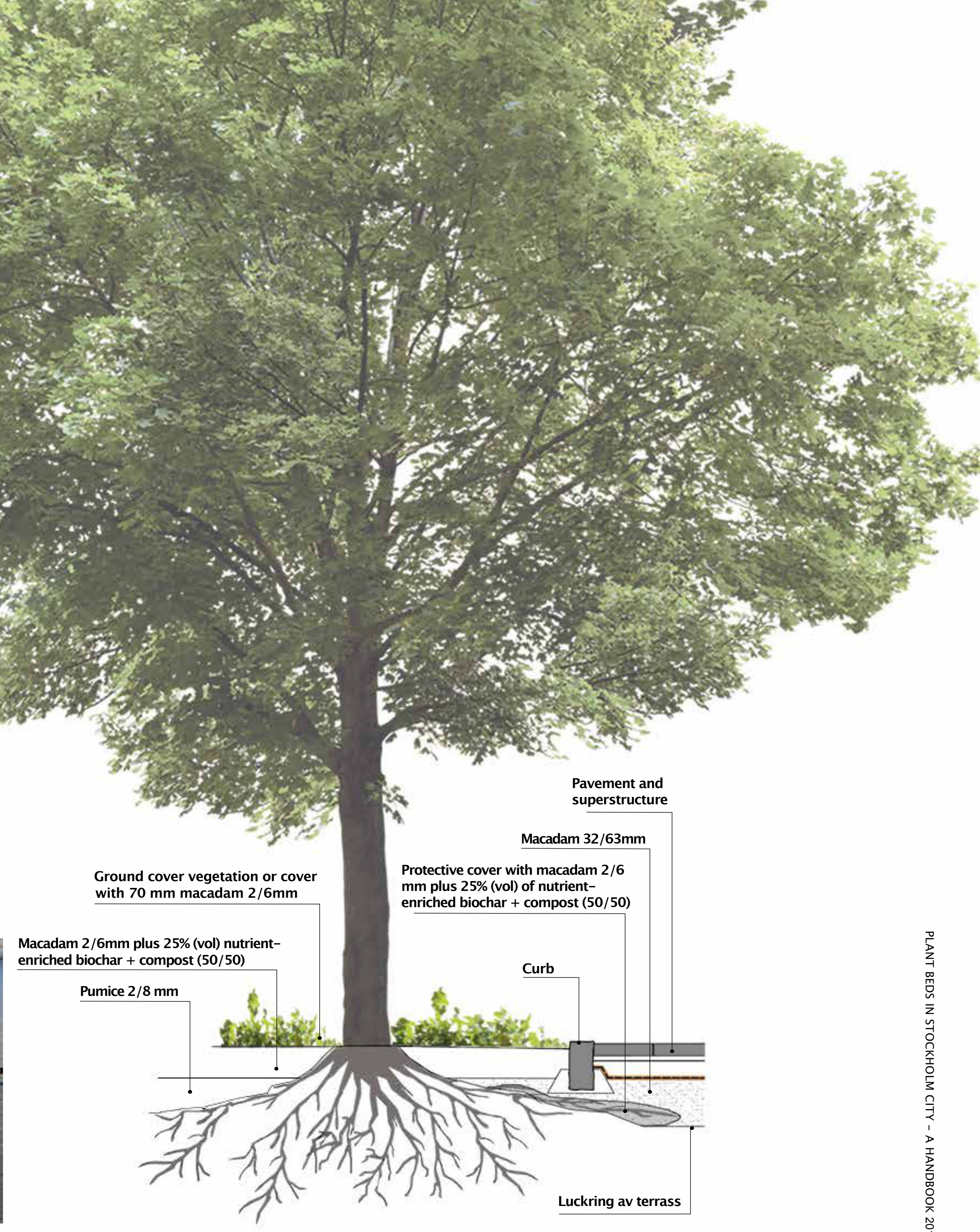


Fig. 4. Restoration after excavation in the root zone.

3. Control, penalties and maintenance

Management and control are important when establishing trees and plants. Proper management ensures that all parts of the construction are carried out in the right way and in the right order. It is advantageous for both clients and suppliers to follow control programs and documentation.

Control program guidelines

Control programs are designed to clarify and quality assure the construction process. They are used to check and document how plant beds have been constructed and how planting and care has been carried out. The control program becomes a security both for clients, construction managers and contractors. In order for a plant bed to be approved by an inspector, the contractor must be able to present a clear documentation of the construction process. The contractor shall measure the plant bed (terraced roof, leveling layer, aeration wells) and deliver as a basis for relational action (see page 15). Soil analysis with grain distribution curve and nutritional analysis for all plant soil should be submitted to the customer. This applies to both existing and manufactured soil.

Documentation of watering down of biochar macadam in structural stone layer. Photo Hildegun Varhelyi.

Checklists and control programs must be written by the contractor and construction manager and approved by the client.

KEY STAGES

Key stages during the construction process must be reported to the customer on an ongoing basis during construction. These stages are photo-documented and delivered digitally to the customer. The construction manager must monitor the construction on site. The ongoing information allows the client or construction manager to respond to errors and correct them before the plant beds are completed.

Key stages in plant bed renovation

HARD SURFACES

- Presentation and control of soil sample analysis and screening curve for stone material
- Exposing roots with gentle excavation
- Protection and irrigation of exposed root system
- Control and possible adjustments to subsoil terrace
- Layering and compaction of structural stones or laying out of biochar macadam.
- Where applicable: watering down of soil substrates into stones (reported for each layer) *
- Installation of aeration well
- Addition of aerated bearing layer
- Addition of leveling layer
- Addition of geotextile layer
- Irrigation

* Refers to plant beds with structural soil

Key stages in new plantings

TREES IN HARD SURFACES

- Presentation and control of soil sample analysis and screening curve for stone material
- Excavation
- Control and possible adjustments to subsoil terrace
- Layering and compaction of structural stones or laying out of biochar macadam.
- Where applicable: watering down of soil substrates into stones (reported for each layer) *
- Installation of tree pit foundations
- Installation of aeration well
- Addition of aerated bearing layer
- Addition of leveling layer
- Addition of geotextile layer
- Delivery and control of plant material and storage
- Planting with soil substrate and watering
- Tree protection, tethering and surface grating

TREES IN VEGETATION AREA

- Presentation and control of soil sample analysis
- Excavation
- Control and possible adjustments to subsoil terrace
- Where applicable: addition of biochar macadam **
- Where applicable: addition of aerated bearing layer **
- Where applicable: addition of leveling layer **
- Where applicable: upper surface removal **
- Delivery and control of plant material and storage
- Planting with soil substrate and watering
- Tree support and tethering

Self-inspection at planting site

The checklist below should be seen as support for construction managers in dialogue with the contractor.

- ☐ Check and review the construction documentation. Pay attention to specially designed details such as tree pit foundations. Check the minimum dimensions and compare with the proposed tree size so that the root ball fits into the proposed tree pit foundation.
- ☐ Review essential parts of the contract with the contractor's staff, e.g. tree planting, preservation of existing vegetation, construction of structural soil and plant bed renovation with vacuum excavation.
- ☐ Take soil samples and check all stone material including structural stones and aerated bearing layer.
- ☐ Establish routine for delivering image documentation of agreed key stages.
- ☐ Check the continuous execution of the key stages in place.
- ☐ Check plant material at delivery. Check the storage of plants. This is especially important in cold weather with temperatures near freezing.
- ☐ Check completion maintenance and warranty maintenance work. (see pages 25-26)

AMA BJB.29

AMA DCL.131 och DCL.149

AMA YCQ.1112

** Refers to plant bed with biochar macadam

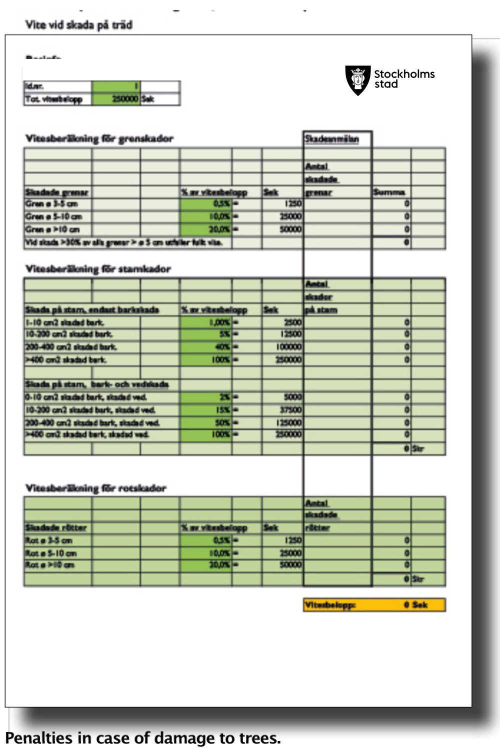
Amount of penalty for damages

Vegetation affected by construction must be protected according to the instructions in SLU's report "Standard for protection of trees during construction" (Östberg. J and Stål. Ö. 2015).

If a tree is to be preserved, a penalty amount is always set. Penalty amounts stipulated must be clearly stated in the documentation so that everyone involved has access to this information. Hence the penalty must be set before the work is started. The penalty is determined by the landowner. The amount of the fine is entered in the City of Stockholm's fine template. Damage to the tree's trunk, roots or crown is assessed by an arborist appointed by the client. The fine is calculated as a percentage of the extent of the damage.

If damage is caused to vegetation that is not affected by the work and therefore does not have a predetermined amount of penalty, the damage is calculated using a calculation model for urban trees, according to SLU's report Financial estimation of the replacement cost of trees, the so-called "Alnarp model" (Östberg, J. Sjögren J. Kristoffersson A. 2015).

If compaction of soil has taken place, the client makes an assessment of damage extent and how it should be restored. If the damage in the tree's root zone is considered to be large, other material can be selected for restoration to repair the damage.



Vite vid skada på träd

Stockholms stad

Id.nr.	1	
Tot. vitesbelopp	250000	Sek

Vitesberäkning för grenskador

Skadade grenar	% av vitesbelopp		Sek	Skadeanmälan Antal skadade grenar	Summa
Gren ø 3-5 cm	0,5%	=	1250		0
Gren ø 5-10 cm	10,0%	=	25000		0
Gren ø >10 cm	20,0%	=	50000		0
Vid skada >30% av alla grenar > ø 5 cm utfaller fullt vite.					0

Vitesberäkning för stamkador

Skada på stam, endast barkskada	% av vitesbelopp		Sek	Antal skador på stam		
1-10 cm2 skadad bark.	1,00%	=	2500		0	
10-200 cm2 skadad bark.	5%	=	12500		0	
200-400 cm2 skadad bark.	40%	=	100000		0	
>400 cm2 skadad bark.	100%	=	250000		0	
Skada på stam, bark- och vedskada						
0-10 cm2 skadad bark, skadad ved.	2%	=	5000		0	
10-200 cm2 skadad bark, skadad ved.	15%	=	37500		0	
200-400 cm2 skadad bark, skadad ved.	50%	=	125000		0	
>400 cm2 skadad bark, skadad ved.	100%	=	250000		0	
					0	Str

Vitesberäkning för rotskador

Skadade rötter	% av vitesbelopp		Sek	Antal skadade rötter		
Rot ø 3-5 cm	0,5%	=	1250		0	
Rot ø 5-10 cm	10,0%	=	25000		0	
Rot ø >10 cm	20,0%	=	50000		0	
					0	Str

Vitesbelopp: 0 Sek

Penalties in case of damage to trees.

Example of damage: the tree has been sawn when mounting the scaffolding.

Warranty Management

General and continuous supervision of the maintenance area is included in the contractor's commitments in both new planting and plant bed renovation. Trees, plants and green spaces should be managed in a professional manner and the plant should look clean and generally attractive. The plants should show good shoot growth and development. Weeding, cleaning and watering should be carried out on an ongoing basis. In connection with the start of watering for the season, spring cleaning is performed, and at the end autumn cleaning is performed. Binding of trees should be kept in good condition and must not damage the tree. Tree support is removed in connection with the guarantee inspection.

Weed cleaning is performed mechanically in such a way that the plants are not damaged. Cutting grass with a trimmer is done with care to avoid bark damage.

Pruning is always carried out in consultation with the client and must be carried out in a professional manner by personnel with documented knowledge of plant care. Any dead and damaged branches are removed continuously, as are root and stem shoots.

HAND OVER INSPECTION

The guaranteed maintenance is usually carried out for two years and ends with a final inspection when the plant is handed over to the respective management. At the end of the guaranteed maintenance period, the plant must have a well-established appearance.

When taking over the inspection, the:

- grass surfaces should be evenly dense and well-cut
- shrubbery and perennials should be fully established, with compact shoots and give a fresh, lush and appealing expression.
- trees should show full establishment and growth and give a fresh and lush impression. They should have fully developed leaves and leading annual shoots should have a satisfactory growth for the species. For newly planted grassland trees, a 10 cm thick layer of hardwood chips should lie within a radius of 50 cm from the trunk. Please note that no wood chips may be used during the guarantee maintenance period, as this will have a negative impact on plant establishment.

Fully established bush area. Photo Lovisa Hell.

Fully established perennial surface. Photo Lovisa Hell.

Fully established city tree.

For multi-stemmed trees, it may be difficult to mount water bags around the trunks. It is easier to mount them against a handlebar. Photo Lovisa Hell.

Maintenance checklist

The checklist below should be seen as support for construction managers in dialogue with the contractor.

- [ ] Tether control - Tree tether should be in good condition and not damage the tree
- [ ] Mechanical cleaning of weeds
- [ ] Irrigation and fertilization
- [ ] Pruning of root and stem shoots
- [ ] Removal of dead and damaged branches
- [ ] Mowing
- [ ] Continuous cleaning and removal of foreign objects
- [ ] Spring cleaning
- [ ] Fall cleaning

AMA DHB.31 (med underkoder)

Irrigation

In order for newly-planted trees to quickly establish themselves, photosynthesis must work. Forming new roots is time-consuming. It may take one to two seasons before the root system of a newly planted tree can supply the tree's ongoing need for water and nutrition.

A well-functioning photosynthesis is dependent on good access to water and all the necessary nutrients. The most common cause of poor development in tree planting is lack of water or nitrogen.

NUTRIENTS

At the time of planting and for a long time to come, most nutrient-absorbing roots are in the root lump. Therefore, it is not enough that the plant soil has a good nutritional status from the beginning.

The absorption of the various nutrients from the soil solution takes place in mineral form. In organic fertilizers, the nutrients must first be transferred to mineral form by means of microorganisms. This mineralization process is dependent on a well-functioning micro-life and this microflora may take time to develop in new planting beds.

By supplying the nutrition in liquid form via a water bag, the existing roots initially have good opportunities to access both water and nutrients. A liquid mineral fertilizer is preferred.

A liquid fertilizer must contain all plant nutrients in a balance that corresponds to the needs of the tree. Substances in excess that cause unnecessary leakage and defects can interfere with photosynthesis. The nutrient content of fertilizers is normally stated as the percentage of nitrogen, potassium and phosphorus, the so-called NPK value. Research carried out at SLU shows that the nutritional needs of plants are very similar. The same fertilizer recipe, NPK 5-1-4, can be used for all species (see Table 1), and fertilizers whose nutrient proportions differ significantly from those listed in the table should not be used, however, a 25% deviation is acceptable.

Depending on the type of fertilizer, if the preparation is solid or liquid and if the substances are in organic or mineral form, the NPK value varies. By converting the NPK value to weight proportions, it is easier to compare different preparations. See examples below:

Calculation example for NPK 11-2-5.

		Proportion
N11		100*
P2	2/11 x 100	=18
K5	5/11 x 100	=45

**Nitrogen is the basis of the comparison and is given the value 100*

EXECUTION

Irrigation should be carried out from 15 April to 30 August. Trees with a stem size of 20-25 cm or larger are irrigated with 140 l every week. This corresponds to two assembled irrigation bags. In the water, 2 per thousand plant nutrients are added during the first two growing seasons. The irrigation may, depending on the weather, need to be extended to September 30, but in such a case can be carried out without nutritional supplement.

The irrigation frequency must be adjusted to weather conditions. The plant bed must never become dry and must be clearly moist down to 300 mm depth. The water should be infiltrated into the plant bed. The irrigation bag is therefore placed directly over the root ball - never out on the wood chips. The bag should be removed when it is emptied after each watering event, to counteract pest problems and prevent its use as a litter bin.

The contractor should report when watering has taken place so that the construction manager can check that the work has been carried out correctly.

Trees in stone flour surface with water bags

AMA DHB.31 (with subcodes)

AMA YCQ.1112

MACRONUTRIENTS	Proportion	MICRONUTRIENTS	Proportion
Nitrogen (N)	100	Iron (Fe)	0.7
Phosphorus (P)	13-19	Manganese (Mn)	0.4
Potassium (K)	45-80	Boron (B)	0.2
Sulfur (S)	8-9	Zinc (Zn)	0.06
Magnesium (Mg)	5-15	Copper (Cu)	0.05
Calcium (Ca)	5-15	Chlorine (Cl)	0.03
		Molybdenum (Mo)	0.003
		Nickel (Ni)	value is missing

Table 1. Necessary nutrients and their ideal interrelationships. Nitrogen forms the basis of this comparison and the yield value 100. Other nutrients are stated as a percentage of the nitrogen content. 20% deviation from these values is acceptable.

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What is in the ground – rock, gravel, sand or clay?

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Text editing, layout and illustrations: Hildegun Varhelyi, Varhelyi + Varhelyi Type
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