TREE CABLING/BRACING

European Tree Cabling/Bracing Standard

European Arboricultural Standards

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EUROPEAN ARBORICULTURAL STANDARDS

Tree Cabling/Bracing Standard	2022

BG: Укрепване на дърветата
HU: Fák kábelezése/abroncsozása
CS: Bezpečnostní vazby stromů
IT: Consolidamento degli alberi
DA: Kronesikring
LT: Medžio kamienų ir lajos sutvirtinimas
DE: Kronensicherung
LV: Koka stabilizācijas sistēmas
EL: Ενίσχυση δένδρων
MT: Irbit tas-siġar ghall-appoġġ
EN: Tree Cabling/Bracing
NL: Stam- en kroonverankeringen
ES: Anclajes de árboles
PL: Wiązania i inne wzmocnienia mechaniczne drzew
ET: Puude toestussüsteemide paigaldamine
PT: Ancoragem, consolidação e suporte de árvores
FI: Latvustuentojen tekeminen
RO: Montarea de ancore în coronament
FR: Standard de haubanage
SK: Bezpečnostné väzby korún stromov
GA: Rásaíocht crann
SL: Povezava krošnje
HR: Standard postupaka stabilizacije stabla
SV: Kronstabilisering

We are very grateful for all the comments and support from national arboricultural representatives and individual arborists across Europe, who responded to the call for cooperation on the text of this standard.

This standard is intended to define the technical procedures used for cabling/bracing amenity trees.

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Editorial:

Standard text:
Working group “Technical Standards in Treework – TeST”

Team of authors:
Jaroslav Kolařík (team coordinator, Czech Republic),
Junko Oikawa-Radscheit (Germany, European Arboricultural Council),
Dirk Dujesiefken (Germany),
Thomas Amtage (Germany),
Tom Joye (Belgium),
Kamil Witkoś-Gnach (Poland),
Beata Pachnowska (Poland),
Valentino Cristini (Czech Republic),
Paolo Pietrobon (Italy),
Henk van Scherpenzeel (Netherlands),
Gerard Passola (Spain),
Daiga Strēle (Republic of Latvia),
Algis Davenis (Lithuania),
Tomáš Fraňo (Slovak Republic),
Goran Huljenić (Croatia).

Text revision:
Simon Richmond (United Kingdom)
Sarah Bryce (United Kingdom)

Pictures:
Olga Klubova (Republic of Latvia)

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EAS 02:2022 (EN) – European Tree Cabling/Bracing Standard.

If you want to translate text of the standard to other languages, please contact the project leader on info@arboristika.cz

Table of Contents:

1. Purpose and content of the standard

1.1 Purpose

1.1.1 This standard was published by the working group of the TeST project (Technical Standards in Tree Work) in cooperation with the EAC (European Arboricultural Council).

1.1.2 In the text of the standard the following formulations are used:
- where the standard says "can", this refers to possible options;
- where the standard says "should", this refers to a recommendation;
- where the standard says "must", this refers to mandatory activities.

1.1.3 The purpose of the standard is to present the common techniques, procedures and requirements related to tree stabilisation with the aims of managing public safety and preserving the integrity of trees. The standard presents common fundamental practices used across European countries.

1.1.4 The stabilisation methods described in the standard include procedures which are common in contemporary arboricultural practice. In specific cases, it may be necessary to use special procedures and combinations of the described methods to achieve the desired stabilizing effect.

1.1.5 This standard sets out safety criteria for arborists and other workers engaged in arboricultural operations. It serves as a reference for safety requirements for those engaged in tree stabilisation works.

1.1.6 Each person must be responsible for his or her own safety on the job site and must comply with the appropriate federal or state professional safety and health standards and all rules and regulations which are applicable to his/her own action. Each person must also read and follow the manufacturer's instructions for the tools, equipment and machinery that he/she uses.

1.2 Main objectives

1.2.1 Cabling/bracing systems or other stabilisation aids are installed, where this is justified by inspection and assessment, on significantly destabilised trees to extend their longevity by improving their biomechanical stability and/or to manage the risk of damage associated with structural failure in the tree.

1.2.2 This standard describes the basic proven methods and procedures used in EU countries. Alternative approaches may be needed in particularly complicated cases of trees with large and/or multiple mechanically compromised parts.

1.2.3 Different practices and preferences, based on national/regional experiences, are listed in the national annexes.

1.3 Biosecurity

1.3.1 People who are professionally involved in working on trees are inherently at high risk of transmitting pests and diseases between trees and worksites and thus should apply appropriate biosecurity procedures to limit this risk.

1.3.2 To reduce the risk of transmitting pests and diseases, the cleaning of tools and other equipment must be part of daily maintenance.

1.3.3 All equipment should be cleaned and disinfected after use on each site. Follow the manufacturer's guidelines.

1.3.4 When work is carried out on trees with a high probability of being infected with contagious pests and diseases, increased biosecurity standards must be applied, such as cleaning and disinfecting tools between trees. National legislation applies.

2. Normative references

2.1.1 This standard is complementary to other EU standards and national/regional regulations.

2.2 Qualification

2.2.1 The installation of cabling/bracing systems and related arboricultural operations are professional activities that can only be performed by a suitably trained and experienced worker or by a trainee under supervision.

2.2.2 Generally accepted proof of an arborist's qualifications is established by international or national certifications. Within the EU, the following certification schemes are recognized for practising arborists:

- European Tree Worker (EAC)
- ISA Certified Arborist
- VETcert Veteran Tree Specialist (Practising level)

2.2.3 The following certification schemes are recognized for consulting arborists:

- European Tree Technician (EAC)
- ISA Board Certified Master Arborist
- VETcert Veteran Tree Specialist (Consulting level)

2.2.4 Meeting the standards of professional qualification includes continuous professional development/lifelong learning.

2.2.5 National qualification references may be recognised locally. These are listed in the national annexes to this standard.

2.3 General safety requirements

2.3.1 Tools and equipment must conform to the requirements of CE and EN standards and certification.

2.3.2 A site-specific risk assessment must be carried out and all relevant control measures, plus briefing for the work, communicated to all workers by the qualified arborist/ supervisor on site.

2.3.3 Traffic and pedestrian control around the job site must be established prior to the start of any arboricultural operations.

2.3.4 Arborists and other personnel working near traffic and operating temporary traffic control zones must be trained in temporary traffic control techniques, device usage and placement, and safe procedures for working near traffic[1].

2.3.5 Arborists and other workers exposed to the risk of highway traffic must wear high-visibility safety clothing which meets the requirements of national regulations.

2.3.6 Arborists and other workers who use any equipment, tools or machinery must be familiar with safe work practices and appropriate personal protective equipment (PPE) usage according to manufacturers' instructions for the tools, machinery and equipment.

[1] Refer to the national annex.

3. Methods of tree stabilisation

3.1 Introduction

3.1.1 Tree stabilisation refers to all methods of linking or supporting branches or stems of a tree with the aim of reducing the probability of failure and/or damage associated with structural failure in the tree.

3.1.2 The overall objective of tree stabilisation is to prevent a branch or tree failing and/or to avoid damage to people or property if failure occurs. Preventing the loss of valuable trees or habitats is also an important consideration.

3.1.3 Tree stabilisation should be considered after a risk-benefit assessment that takes into account the risk of significant damage to people, property or to the remaining tree structure, the probability of failure and the tree's value.

3.1.4 Tree stabilisation systems can disturb or stop natural retrenchment processes and branch shedding, which are part of a tree's natural structural changes.

3.1.5 Professionals with knowledge of the various cabling/bracing systems available should carry out the design and installation of tree stabilisation systems in order to ensure suitable equipment is selected and correctly positioned. Only specialists with sufficient expertise should design and install tree stabilisation in biomechanically complex trees.

3.1.6 All tree stabilisation systems need to be recorded and monitored, with regular inspection, maintenance or replacement. A maintenance plan must be drawn up and handed to the tree owner (see section 5). Record keeping and establishing an inspection/ maintenance regime are essential parts of the work and this must be considered when recommending and installing tree stabilisation systems.

3.1.7 Full documentation must be provided to the tree owner/manager for each stabilisation system installed.

3.1.8 Materials, components and systems for tree stabilisation must have a minimum service life of 8 years.

3.1.9 Ensure the installed tree stabilisation system has sufficient weight-bearing capacity.

3.1.10 Typically, the strength of a system is declared as the minimum breaking strength (in newtons [N]). Sometimes this is converted to a breaking load or load-bearing capacity (in kilograms [kg] or tonnes [t]).

3.1.11 Tree stabilisation work can incorporate materials and/or systems that are certified or non-certified for use in trees. If non-certified materials or systems are used, the design, combination of materials, material properties and minimum breaking strength of the stabilisation system are the responsibility of the professional who designs and/ or installs the stabilisation system. The specification for the complete system, including the materials used, must be part of the final documentation.

3.1.12 Tree stabilisation systems designed to alleviate strain at specific points (e.g. forks, branch junctions) can alter the force distribution in the tree and, as a consequence, reduce the natural reactive growth of the tree. This must be considered and taken into account before work begins on designing the system.

3.1.13 The impact of stabilisation systems on the redistribution of forces in trees must be considered, even though the dynamic (frequency, damping) and static (stress/strain distribution) mechanical response to wind load, both in general and individually for the stabilised tree, cannot be precisely predicted. Increasing the number of cablings/bracings in the crown influences the crown dynamics (damping) and can increase the stress on lower load-bearing parts of the tree including the root system.

3.1.14 Any stabilisation system must not be installed if it is likely to increase the risk of tree destabilisation in the future.

3.2 Target modification

3.2.1 A target is considered to be an object, person or property etc. which could be affected by failure of the tree or its parts.

3.2.2 To lower risk to an acceptable level, first consider moving or modifying the target before considering pruning or other tree stabilisation methods.

3.2.3 Main advantages:
- no interference with the tree;
- possible biodiversity support.

3.2.4 Main disadvantages:
- target modification might not be possible;
- restrictions to traffic around the tree;
- risk of tree failure remains.

3.3 Stabilisation by tree pruning

3.3.1 Pruning is generally the preferred method for long-term tree stabilisation, when it is carried out in line with good practice (see EAS 01: 2021 – European Tree Pruning Standard). However, some biomechanical features can be managed by preventive cabling/bracing without impacting the tree's physiology.

3.3.2 Stabilisation of parts of tree crowns can usually be achieved by means of lateral crown reductions.

3.3.3 Stabilisation of the whole tree (including the root system) can be achieved by upper crown reduction. This intervention must be designed in such a way that there is no significant disruption to the physiological vitality of the tree. It is also necessary to consider the effect of the reduction on the dynamic behaviour of the crown (see EAS 01: 2021 – European Tree Pruning Standard).

3.3.4 Main advantages:
- no artificial systems in the tree;
- no restrictions on the natural movements of branches;
- opportunity to carry out corrective pruning and crown cleaning.

3.3.5 Main disadvantages:
- pruning wounds;
- possible reduction of vitality;
- possible influence on crown dynamics;
- altering the form of the crown;
- ongoing maintenance necessary due to regeneration processes.

3.3.6 Additional tree stabilisation by cabling, bracing or propping may be necessary when the amount of pruning required to reduce risk to an acceptable level would compromise the tree's viability or cause the loss of the structure of a remarkable tree.

3.3.7 Additional tree stabilisation by cabling, bracing or propping can be applied as a temporary measure during a multi-stage pruning process, working towards an acceptable level of risk without a stabilisation system.

3.4 Dynamic cabling

3.4.1 Dynamic cabling systems are used to reduce the probability of tree or branch failure by eliminating stress peaks, by damping energy during rope elongation (stretching). In some situations, dynamic cabling can also be used as a preventive measure to catch a branch (or unstable parts of the crown) in the case of failure.

3.4.2 Dynamic cabling systems have an overall elasticity of 5–25%.

3.4.3 Dynamic cabling systems generally consist of polyester, polypropylene[2] or polyamide cables[3].

[2] If installed with shock absorber.
[3] Jahrbuch der Baumpflege 1998; Schröder et al.

Table 1: Overview of basic properties of materials, used for dynamic cabling systems

Material properties	Polyester (PES)	Polyamide (PA)	Polypropylene (PP)
Elasticity	ca. 5%	ca. 20%	ca. 5%
Strength reduction when knotted	50–60%	50–60%	35–50%
Strength reduction due to moisture	0%	10–(max) 30%	0%
Creep under long-term stress	near to 0%	1–2%	3–5%
UV resistance	excellent	good	only when blackened

3.4.4 Main advantages:
- preservation of the crown form;
- minimal loss of crown volume;
- movement reduction of branches susceptible to failure;
- reduces required pruning.

3.4.5 Main disadvantages:
- possible hindrance to natural movements;
- artificial system in the tree;
- regular inspection and maintenance required;
- installation is dependent on presence of stable limbs and branches.

3.5 Static cabling

3.5.1 Static cabling consists of components made of materials with low elasticity. To be considered static, the complete system has elasticity below 2% within the defined bearing capacity.

3.5.2 Static cabling is installed under tension (preloaded). This might involve pulling the stabilized parts together during the installation process.

3.5.3 Static cabling should be installed in a way that means it will have a long service life without negatively influencing the tree. If possible, a static system should only be replaced when there is a technical need to do so. Synthetic static ropes have a limited service life and should therefore only be used for temporary stabilisation solutions.

3.5.4 There are many static cabling systems (listed in Table 3). As a result of local experience, different countries prefer, or discourage the use of, different systems. Check the national annex.

3.5.5 Materials used for static cabling can be static (synthetic) ropes, steel cables or other steel products (systems). Metal materials and components must be corrosion resistant (e.g. zinc coated as a minimum). All metal materials and components must be made of the same metal (no mix of stainless steel/zinc/steel), otherwise electrolytic corrosion problems can occur.

3.5.6 Static cabling is used to rigidly stabilize stems or branches which show signs that they might fail in the future (broken forks, rips etc.).

3.5.7 Static cabling must be located in the static (lower) part of the crown.

3.5.8 Static cabling changes the strain distribution in and influences the natural reactive growth of the tree (self-optimization).

3.5.9 Static cabling can increase overall tree stiffness and reduce the tree's ability to deal with dynamic loading, due to lowered mass damping. Therefore, special attention must be paid to the installation of static cabling on trees which are mechanically compromised at the stem base and/or in the root system.

3.5.10 Static cabling systems are:
- drilled cabling; (steel cable attached to eye bolts drilled through stem)
- cable-and-slat systems to secure cable around stem;
- belts connected with static rope (steel, synthetic) or chain.

3.5.11 Main advantages:

- preservation of the crown form;
- no loss of crown volume;
- immobilization of stems/limbs/branches susceptible to failure;
- no or minimal pruning required.

3.5.12 Main disadvantages:

- impact on natural crown dynamics;
- local damage to the tree when drilling is involved;
- possible problems with growing-in if belts or slat-and-cable system are used;
- artificial system in the tree;
- regular inspection and maintenance required;
- limited possibility of installation on stems/limbs/branches with active fungal decay

3.6 Static bracing (rods)

3.6.1 Static bracing consists of steel rods put through the tree at the base of stems/limbs/branches or directly through a fork.

3.6.2 Static bracing is used to rigidly stabilize stems or branches which show signs that they might fail in the future (broken forks, rips etc.).

3.6.3 This kind of stabilisation is not recommended when the part of the tree to be braced contains decayed wood or cavities because installation carries a risk of damaging internal barrier or reaction zones and the possibility of mechanical damage to the tree in the case of a thin residual wall.

3.6.4 Main advantages:

- can be used for branches growing very close to each other;
- low level of maintenance required;
- no reinstallation necessary;
- provides a very strong, secure brace;
- no or minimal pruning required.

3.6.5 Main disadvantages:

- potential impact on the crown dynamics;
- artificial system in the tree;
- damages ripewood/heartwood and may facilitate internal dysfunction;
- once it is installed, modification or adjustment is difficult;
- limited possibility of installation on stems/limbs/branches with active fungal decay.

3.7 Propping

3.7.1 Propping refers to all ground-based methods of holding a tree or a branch up to stop it from falling.

3.7.2 Props can be wooden or metal structures, simple or complex. They are fixed to the stem or branch and do not allow the secured part to move.

3.7.3 The design for a prop must be produced by specialists, taking into account the expected loads, including the effects of side load and wind influence. The cooperation of experts in the design and the supervision of an experienced arborist during installation are essential[4].

3.7.4 Factors to consider when designing a prop are:

- material to be used;
- planned lifespan;
- prop's contact with the secured part;
- how the prop will be fixed in the ground;
- location of the prop;
- possibility of adapting the prop to the growth of the tree;
- possibility of future replacement;
- aesthetic influence on the tree and its surroundings.

A prop installation must be designed specifically for the tree in question.

3.7.5 Main advantages:

- protection of stems/limbs/branches susceptible to failure;
- no or minimal pruning required.

3.7.6 Main disadvantages:

- highly visible artificial system in the tree;
- future maintenance necessary;
- possible interference with the root system;
- impact on tree dynamics;
- regular inspections and maintenance required;
- risk of damage through vandalism.

[4] Many countries have laws that demand a calculation of the bearing capacity of the prop system.

3.8 Less common or historical tree stabilisation systems

3.8.0 For very valuable (veteran) trees with complex biomechanical structures, the standard stabilisation systems described above might not be sufficient to fully stabilize the tree or to lower risk to an acceptable level. In these cases, it might be necessary to resort to less common tree stabilisation systems. Some of the systems used in the past have been abandoned because of their negative impact on tree physiology. In rare cases, as a last resort to save valuable trees, these less common or historical techniques might still be applicable.

3.8.1 Compression belts

3.8.1.1 Compression belts are usually metal belts installed around the stem, mostly in old (veteran) trees. The intention is to keep the stem together and prevent shell buckling. Sometimes this work has been done to stop important habitat (such as decayed wood) falling out of the tree.

3.8.1.2 Although metal compression belts were installed in the past, this technique is currently not widely used as installation affects the tree's static and dynamic behaviour and its physiology: the cambium can be squashed or suppressed and compression decay can be triggered as functional units in the tree die.

3.8.1.3 Installation needs to be carefully evaluated by the consultant designing the system, on a case-by-case basis, keeping in mind not only risk management but also respect for the tree's physiological function.

3.8.1.4 A compression belt can be a bespoke metal belt that is bolted together, a ratchet strap (similar to those used by lorry drivers) or a steel cable running through eye bolts.

3.8.1.5 In the case of metal belts or ratchet straps, the physiological functions of the tree are impacted because the bands limit radial growth. Regular monitoring and adjustment may be required.

3.8.1.6 Main disadvantages:
- highly visible artificial system in the tree;
- future maintenance necessary due to continual in-growing in the stem;
- risk of damage through vandalism.

3.8.2 Tethering/guy ropes

3.8.2.1 Tethering refers to a tree being attached with guy ropes to another tree or to a ground anchor to prevent it from falling in a direction where it might cause damage to a non-movable target, or to reduce the risk from the tree to an acceptable level.

3.8.2.2 As a rule, one or more ropes are spanned from the crown to the ground. Ropes are secured to the ground via a stable anchor point.

3.8.2.3 Steel cables, high-strength (low-elasticity) synthetic ropes or combination of both are used for this purpose.

3.8.2.4 When guy ropes are installed, the approach must be adapted to the tree in question. The following issues must be considered:
- effect of side (wind) load;
- carrying capacity of the system;
- condition of the tree at the attachment point;
- strength of the anchor point.

3.8.2.5 If there is a risk of vandalism, it should be taken into account in the overall design of the system.

3.8.2.6 Main advantages:
- preventing tree failure or damage to targets;
- possibility of stabilizing trees with root stability problems;
- minimal pruning required.

3.8.2.7 Main disadvantages:
- highly visible artificial system in the tree;
- future maintenance necessary due to continual in-growing in the stem;
- risk of stem/branch failure above the installation point;
- risk of damage through vandalism.

3.8.3 Interconnected trees

3.8.3.1 Interconnecting the crowns of neighbouring trees by means of static or dynamic systems is an infrequent solution to the problem of stabilizing a significantly damaged tree.

3.8.3.2 This type of stabilisation can be designed and installed only after a detailed survey of the condition of the anchor trees to determine their resistance to both breakage and uprooting.

3.8.3.3 The installation of an interconnected tree stabilisation system depends on its type but in principle does not differ from the installation of a given type of bracing within the crown of one tree.

3.8.3.4 Main advantages:
- preventing tree failure or damage to targets;
- possibility of stabilizing trees with root stability problems.

3.8.3.5 Main disadvantages:
- possible influence on anchor trees.

4. Stabilisation methods

4.1 Introduction

4.1.1 Crown cables are ties between parts of the crown which are at risk of structurally failing. The parts of the crown to which the cables are attached must be capable of bearing the additional loads.

4.2 Geometry of connections (horizontal)

4.2.1 Options for cabling geometry include:
- direct connection;
- triangular configuration;
- ring-shaped (floating) configuration.

4.2.2 A **direct connection** is installed between two branches/stems and only deals with the loading in the direction of the ties (ropes or cables). Lateral sway of the secured crown parts is not eliminated. A destabilized branch should be supported by a stable branch (or stem) of the same or bigger diameter.

4.2.3 **Triangular configuration** can offer support for the secured part of the crown in more than one direction. A system of one or more triangles is designed to form a network of connections that reduces swaying in several directions. This installation method also serves to dissipate wind energy to several parts of the crown through the ties.

4.2.4 **Ring-shaped (floating) connection** deals only with lateral swaying forces. This rare type of design offers an opportunity to avoid excessive pruning, especially in secondary crowns and when securing regrowth that occurs after topping.

Figure 1: Example of direct connection

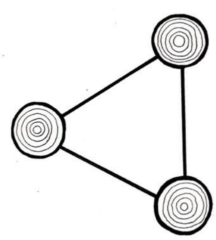

Figure 2: Example of triangular connection

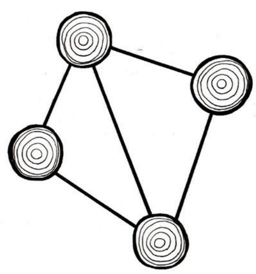

Figure 3: Example of combined triangular connection

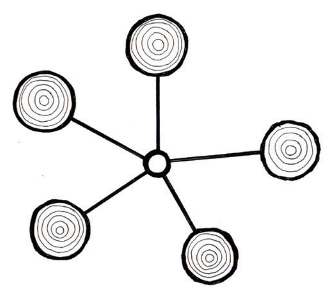

Figure 4: Example of ring-shaped connection (general view)

4.3 Height of installation

4.3.1 In general, dynamic systems are installed all in the same plane.

4.3.2 Dynamic systems should be installed preferably in the upper (dynamic) part of the crown, or at least in the top half measured from the location of the fork.

4.3.3 If a dynamic system is not combined (multi -level), it should preferably be positioned ⅔ of the way up the branch/stem length (measured from the fork). The stability of the anchor point and the aims of the stabilisation must be considered.

4.3.4 By adjusting the height of installation (and the appropriate slack in the system, the addition of a shock absorber etc.), a system can be made more or less dynamic (semi-dynamic/semi-static).

4.3.5 Static systems should be installed in the lower ¼ of the crown (measured from the fork), preferably as close to the junction as possible.

4.3.6 All forces coming from the crown concentrate at the level where a static (pre-loaded) system is installed and all other stabilisation systems below it may become mechanically less functional.

4.3.7 Static systems can be combined with dynamic systems and installed higher in the crown to alleviate mechanical loads on the stabilised parts. The dynamic systems can be provisional – installed in order to let the tree adapt to the new static stabilisation system.

4.3.8 In a bespoke stabilisation system created for a specific situation, the design should consider the crown dynamics set out in Figure 5. Note that the elasticity of young trees is much higher than in an older specimen.

4.3.9 **Multi-level stabilisation systems** should be considered in the following cases:

- combination of static and dynamic systems, especially for tall trees;
- highly branched trees or long horizontal branches;
- when destabilised branches/stems are located immediately above a target.

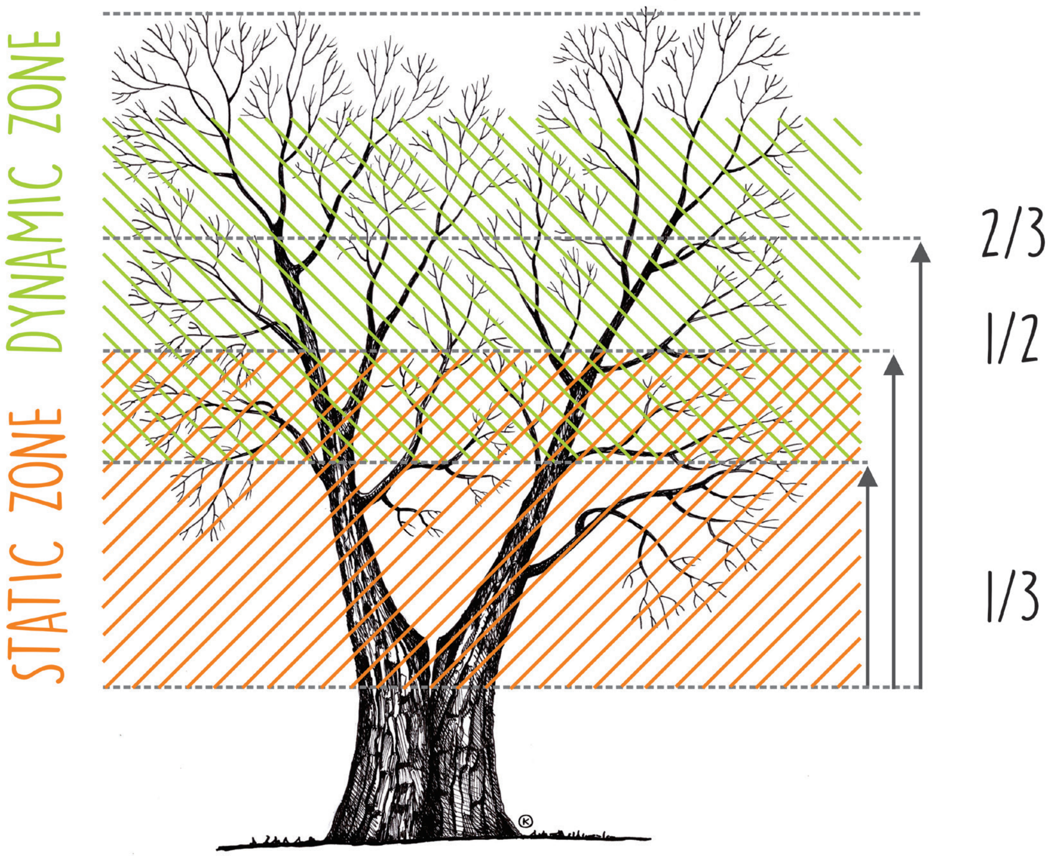

Figure 5: Height of installation

4.3.10 The **length of the ties** (ropes or cables) and their location should be designed so that in the event of a branch failure, the secured part is retained. If the stabilised part fails, damage to the target can be minimised by a properly installed stabilisation system.

4.3.11 To stabilize a **horizontal branch**, both its base and tip should be secured by separate ropes to reduce the risk of damage. Consider the dimensions and positioning of both ropes in respect to their angle.

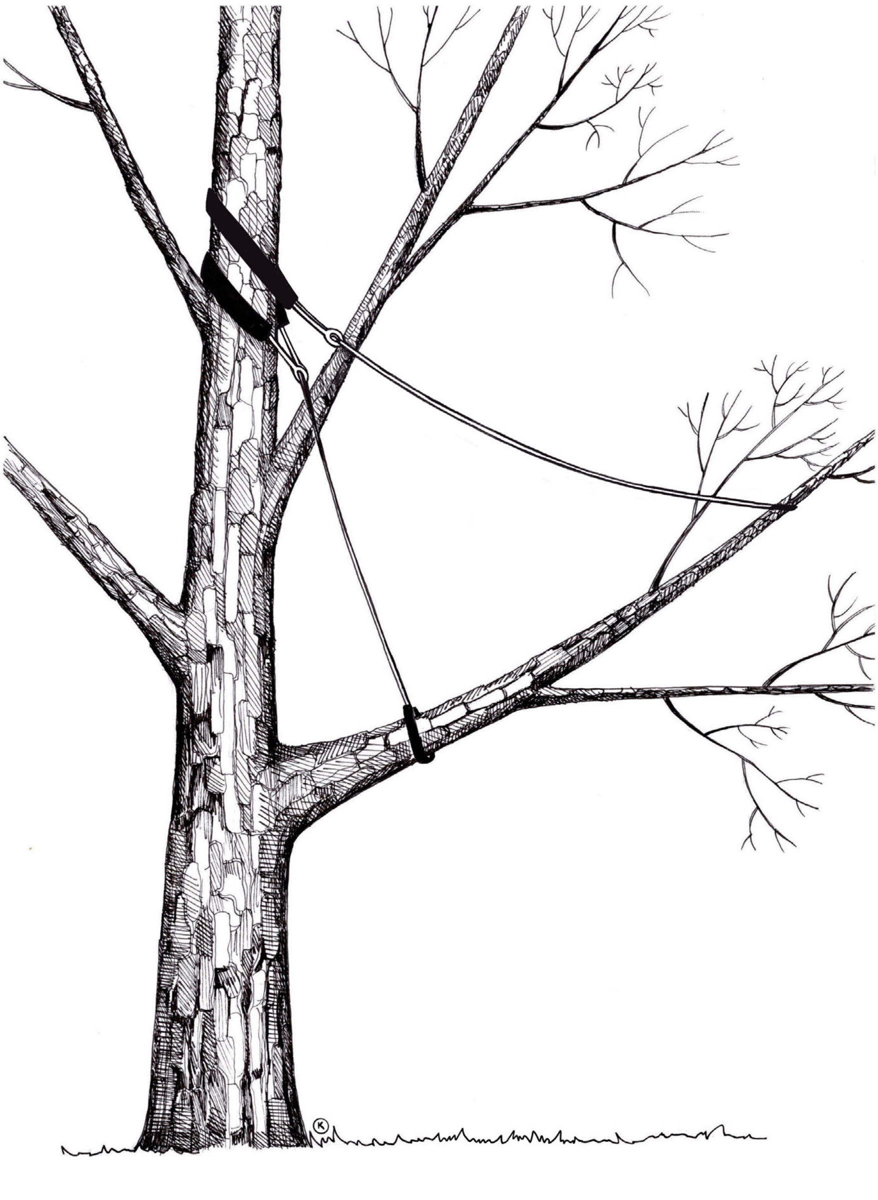

Figure 6: Securing a horizontal branch to prevent damage in the event of failure

4.4 Angle of ropes

4.4.1 The forces acting upon ropes and their anchor points change with the angle of the ropes' installation in relation to the direction of load. The difference between a 90-degree and a 30-degree angle can increase the load by 100%. Therefore, it is necessary to consider increasing the load specification for ropes and anchors in cases where they are installed with oblique loading.

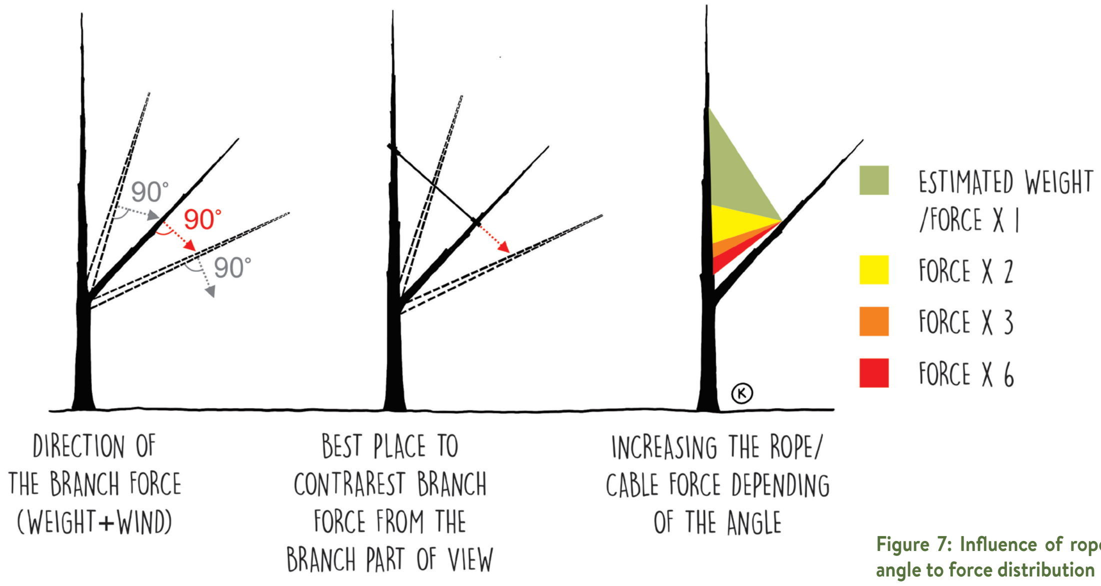

Figure 7: Influence of rope angle to force distribution

4.5 Dynamic crown stabilisation systems

4.5.1 Only use systems supplied with detailed instructions by the producer/manufacturer. The information required includes:

- minimum breaking strength of the complete system;
- installation procedure (manual);
- prescribed control regime (e.g. basic/detailed inspection) and timing (e.g. annual inspection);
- maximum service life in the tree[5].

4.5.2 Dynamic systems require regular monitoring and adjustment (in line with manufacturer's instructions).

4.5.3 Dynamic systems must be installed in the dynamic part of the crown and must be proportional to the movements at that location in the tree. They must be installed with slack in the rope with allowance for future tree growth and seasonal changes (see 4.5.12).

4.5.4 Note that dynamic cabling systems can be damaged, e.g. by friction or squirrels.

4.5.5 To prevent friction damage, ropes in the crown must not touch each other or come into contact with branches (even small ones).

4.5.6 A cover must be installed around a rope if this cannot be avoided.
Some dynamic cabling systems are delivered with positioning belt, which is installed around stems. Use of positioning belt is described in manufacturer's instructions.

4.5.7 During the installation of cabling systems, the manufacturer's instructions must be followed. It is recommended that all parts of the system come from the same manufacturer.

4.5.8 The load-bearing rope and stem attachment should be connected as follows:

[5] Minimum service life is 8 years according to 3.1.8.

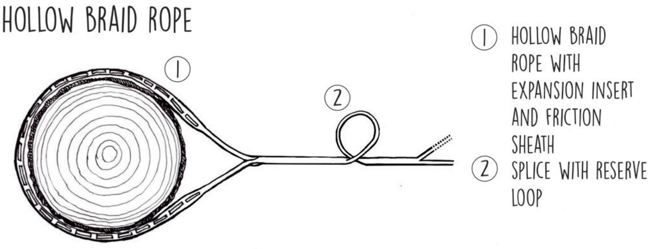

Figure 8: Connection of hollow braid rope (rope connection can vary according to the manufacturer's instructions)

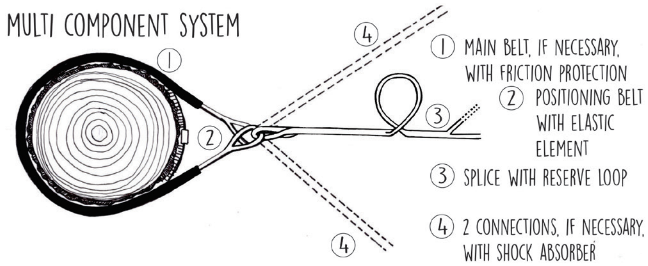

Figure 9: Connection of multi-component system

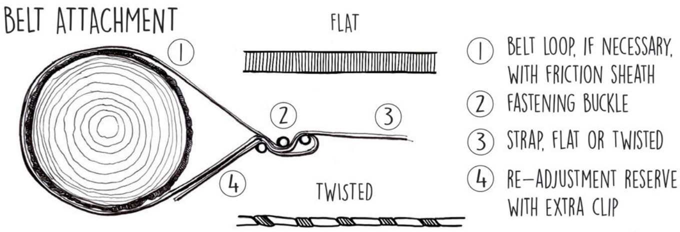

Figure 10: Connection of belt

4.5.9 The distance between the branch and the interlock should be at least 0.5× the branch diameter at the installation point (Figure 11).

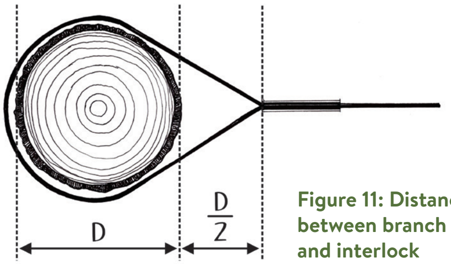

Figure 11: Distance between branch and interlock

4.5.10 The eye of the interlock (attachment point) must be covered (to avoid friction between the rope and branch).

4.5.11 The interlock must be fixed according to the manufacturer's instructions.

4.5.12 Dynamic cabling systems must be installed with slack (see Figure 12):
- for ropes up to 5 m in length, aim for 10–15% of slack;
- for longer ropes, aim for 5–10% of slack.

Also consider the expected movement of the secured branches.

4.5.13 In some cases more or less slack is acceptable, based on expert judgement (see also 4.5.21). Slack must be calculated for the period when the tree is in leaf. In winter, the slack can exceed these values in deciduous species.

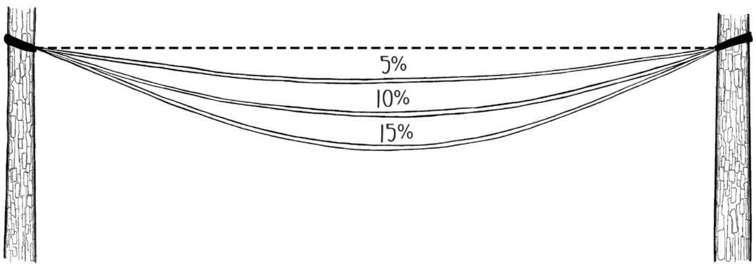

Figure 12: Demonstration of slack in a dynamic cabling system

4.5.14 There must be a sufficient reserve of rope left behind the interlock or in the incremental loop to allow the system to be released during detailed inspections.

4.5.15 It is possible to use more than one cabling system in a tree or a combination of dynamic and static systems if needed, depending on the extent of the mechanical destabilisation and crown size.

4.5.16 Careful consideration must be given to the branch length, rope angle, mass of branches, height of installation and the wind force. In some cases, more detailed load analysis is advisable.

4.5.17 Suggested minimum strengths for dynamic systems[6] is presented in the Table 2.

Table 2: Suggested minimum strengths for dynamic systems

Stems/limbs diameter at the base [mm]	Minimum rope breaking strength [kN]
up to 400	20 (2 t)
400–600	40 (4 t)
600–800	80 (8 t)
more than 800	bespoke set-up for each individual case

4.5.18 A system is only truly dynamic if the forces applied to it are actually big enough to deform the material. If a system is over-dimensioned (even with elastic materials), it will be static in nature because the forces applied to it will be too low for elastic deformation of the material.

4.5.19 Therefore, the minimum breaking strength of dynamic systems should not significantly exceed the values stated at Table 2, to avoid the risk of unexpected shock loads.

4.5.20 The declared minimum breaking strength of the complete system must be retained throughout its service life in the tree (until date of expiration).

4.5.21 There are several ways of using dynamic systems:

- **“breaking prevention”** system – installation with slack in line with 4.5.12;
- **“damage prevention”** system – installation with greater slack to allow natural movement and to serve only to catch branches/stems if they fail. Attention must be paid to necessary breaking strength of materials as a fall factor might be expected;
- **“braided” system** (see Figure 13) – for securing tops of trees or branches to prevent their parts from falling to the ground, in cases where there is no sufficient anchor point (self-retention system). Attention must be paid to the required breaking strength of materials as a fall factor is to be expected.

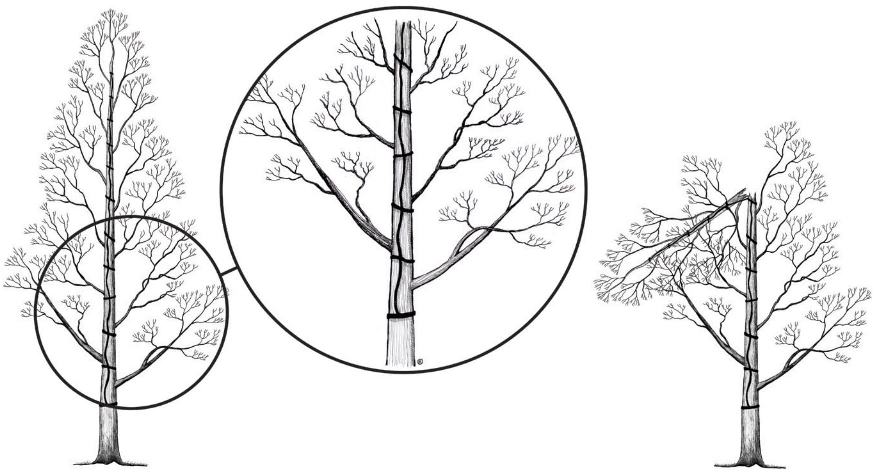

Figure 13: Example of “braided” system

6 Source : ZTV Baumpflege

4.6 Static crown stabilisation systems

4.6.1 Static stabilisation systems can be installed in various configurations using a variety of materials[7]. Table 3 lists methods used in European countries. However, there may be substantial differences between the methods preferred in different countries/regions (see national annex):

Table 3a: Overview of static crown stabilisation systems

Method	Technique	Advantages	Disadvantages
Synthetic rope	Synthetic static rope is connected to a synthetic belt, which is tied around the branch or stem. This should only be used as a temporary stabilisation system.	· Easy installation. · If appropriately installed (correct tension/protective tubing/…), causes minimal damage to the tree at the time of installation.	· The rope should be installed under tension, which causes a tight connection between the belt and branch. There is a high probability that the belt will quickly be subsumed by the tree/branch and thus cause damage. · The rope is sensitive to friction and can be damaged (by vandalism, squirrels etc.).

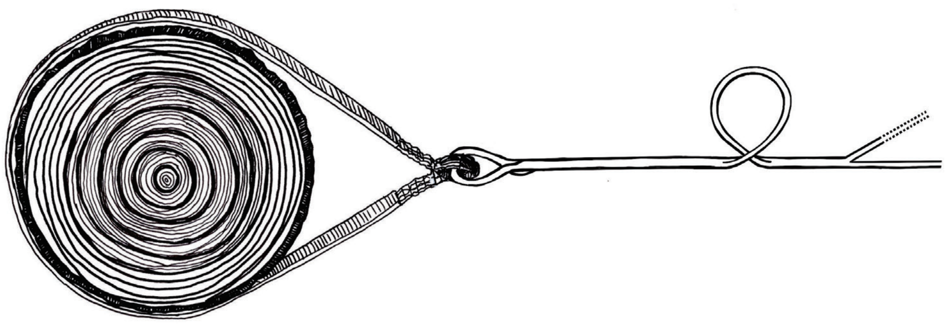

Figure 14: Connection of a static system using synthetic rope

[7] Source: VETcert fact sheet, edited.

Table 3b: Overview of static crown stabilisation systems

Method	Technique	Advantages	Disadvantages
Cable-and -slat wrapped around the branch/stem	Steel cable connects branches and is wrapped around the slats. This system is recommended in cases where branch/stem decay is expected at the installation location.	• If appropriately installed (correct tension/form of slats/...), causes minimal damage to the tree. • Can be used on partially decayed branches/stems where residual wall thickness is sufficient.	• Demanding to install. If not installed and controlled properly, slats can cause damage to the branch, or can fall out. • In extreme wind, the movement of branches can release the tension on the system and the connection between rope and slats can be damaged.

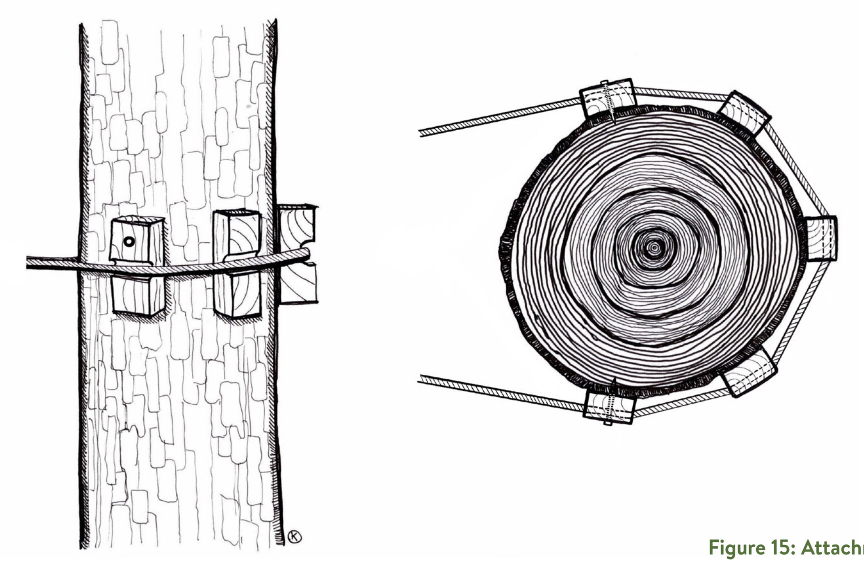

Figure 15: Attachment of the cable-and-slat system

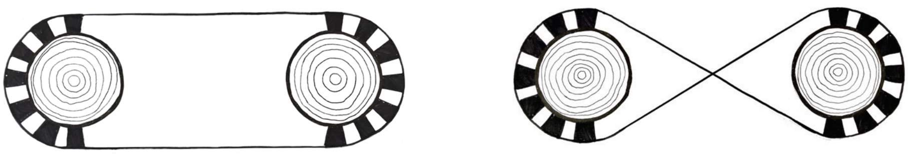

Figure 16: Recommended ways of installing the cable-and-slat system

Table 3c: Overview of static crown stabilisation systems

Method	Technique	Advantages	Disadvantages
Steel cable connected to eye bolts or threaded rod with eye-nuts, drilled through the stem.	A hole is drilled through the branch/ stem strictly in the line of the cable, through which a threaded rod or eye bolt is installed, secured by a washer and nut. A steel cable is attached to the eye bolt or eye-nut. The crushing of the cable at the point, where it is attached is prevented by thimbles. It is good practice to drill a hole of the same diameter as the installed threaded rod /eye bolt (not larger) and to use large washers, which must be in full contact with the living sapwood (remove bark).	• No reinstallation needed. • Possibility of integration into secured parts by radial growth.	• Damages ripewood/heartwood and might trigger or accelerate the development of decay. • Can be more demanding on skills and experience when installed on large-diameter branches/stems due to the requirement to drill a straight hole all the way through. • Cannot be installed where there are signs of fungal decay and cavity.

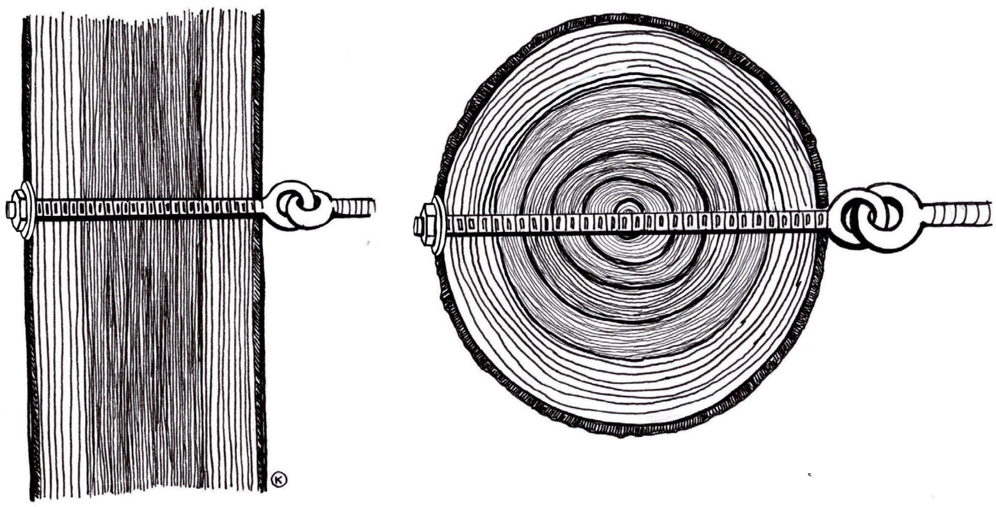

Figure 17: Detail of the drilled static system

4.6.2 All load-carrying components need to have sufficient minimum load-bearing strength to last for the whole service life of the system.

4.6.3 Minimum strengths for static systems[8] is presented in the Table 4.

Table 4: Suggested minimum strengths for static systems

Stems/limbs diameter [mm]	Minimum breaking strength [kN/t]
up to 400	40 kN (4 t)
400–600	80 kN (8 t)
600–800	160 kN (16 t)
more than 800	bespoke set-up for each individual case

4.6.4 In some specific (unusual) cases, more detailed load analysis is advisable.

4.6.5 Tree owners/managers must be provided with a schedule in which all the materials and components used are listed.

4.6.6 Metal materials and components must be corrosion resistant (e.g. zinc coated as a minimum). All metal materials and components must be made of the same type of metal (no mix of stainless steel/zinc/steel), otherwise electrolytic corrosion problems will occur.

4.6.7 Steel cables in the crown must not touch each other.

4.6.8 Each steel cable must be fixed with the appropriate number of cable grips in the prescribed arrangement (U-bolt of the grip on the dead end of the cable and saddle of the grip on the live end – see Figure 19-20) and with the prescribed torque, as defined by the manufacturer. The torque of the clamps must be checked with a torque wrench. Appropriate swage clamps can also be used.

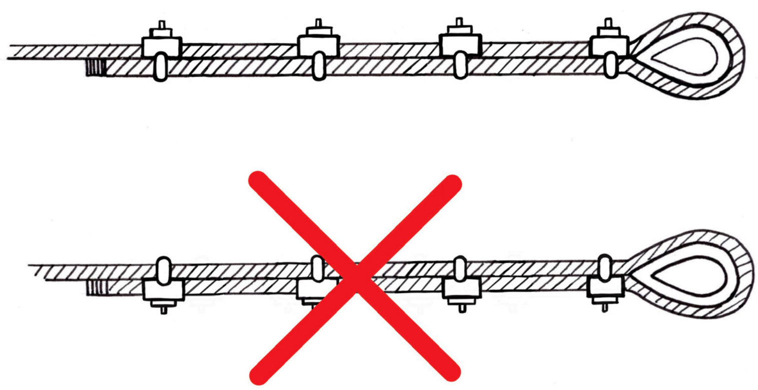

Figure 18: Position of cable grips for fixing cable (number of cable grips depends on cable diameter)

[8] Source : ZTV Baumpflege

Table 5: Number of and distance between cable grips according to cable diameter.[9]

Cable diameter [mm]	Min. recommended number of cable grips	Recommended distance between cable grips [mm]
6–7	2	120
8	3	133
9–10	3	165
11–12	3	178
13	3	292
14–15	3	305
16	3	305

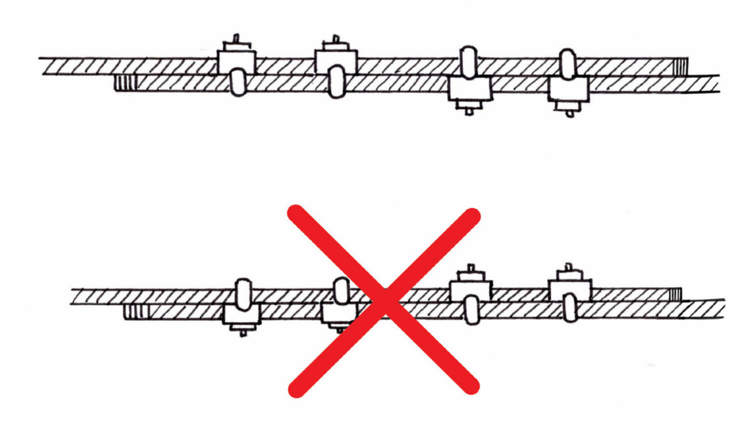

Figure 19: Position of cable grips in circular cable installation (number of cable grips depends on cable diameter)

4.6.9 When two independent continuous cables (circular installation) are connected, twice the number of cable grips are used than recommended for a given cable dimension.

4.6.10 If shackles are used, they must be of adequate quality (breaking strength) and suitable configuration.

4.6.11 Synthetic ropes must be fixed with the interlock recommended by the manufacturer.

4.6.12 The cable must not touch the tree, or any other object, unless it is protected in some way, e.g. with a tubing or connected to a belt (with the exception of cables going directly through the stem).

4.6.13 For systems which are drilled through the stem:

- bored holes should not go through branch collars;
- a vertical distance of at least 50 cm is recommended between holes bored on the same branch/stem to prevent cracks forming between them.

4.6.14 For the cable-and-slat system:

- the system must be installed under tension to ensure the positions of the slats remain fixed (to avoid loosening in the wind);
- a distance of at least 2 cm must be maintained between the rope and stem at the time of installation;
- slats from hardwood species are recommended; they should be of sufficient width and length to prevent the stem growing over them;
- the space between slats should be more than their width (the optimum is 2 their width or more);
- the shape and design of the slats must prevent the rope from shifting and falling out;
- slats which are at not permanently under tension, i.e., the outer ones, should be fixed.

9 Source: DIN EN 13411-5:2009-02: Terminations for steel wire ropes – Safety – Part 5: U-bolt wire rope grips.

5. Record keeping, controls, maintenance and replacement

5.1 Introduction

5.1.1 Every cabling system must be inspected regularly at intervals specified by the manufacturer. The schedule for inspections and for any additional work to be carried out should be provided to the tree owner/manager.

5.2 Record keeping

5.2.1 To facilitate periodic inspections of stabilisation systems and to monitor their maximum service life, records must be kept for trees with installed crown stabilisation systems.

5.2.2 After installation, the arborist must record information about the system installed and deliver it to the tree owner. This information should be uploaded to a tree management information system.

5.2.3 Records of stabilisation systems must include the following information:

- location (tree position);
- installation date;
- reason for the stabilisation (relevant biomechanical feature);
- contact details of the installing arborist or company ;
- proposed inspection interval or date;
- type of stabilisation system (dynamic, static etc.);
- height (level) of installation;
- brand and model of stabilisation system (commercial name) if applicable;
- nominal carrying capacity (minimum breaking strength) of stabilisation system;
- number of ties (ropes, cables, braces, props etc.);
- maximum service life of the system.

5.2.4 It is advisable to use a tree management information system that allows recording of routine monitoring and inspections and issues an automated warning of the end of service life of the stabilisation system.

5.3 Basic inspection

5.3.1 In general, basic inspection of a stabilisation system (and a stabilised tree) is carried out at least once every year. Additional inspection after exceptional events (e.g. severe weather, earthquake etc.) should be considered. In some cases, different inspection periods may apply.

5.3.2 The basic inspection is usually done from the ground, with binoculars, without ascending to the crown.

5.3.3 The optimum time for the basic inspection is during tree dormancy (when trees are without leaves).

5.3.4 The following parameters must be inspected as a minimum:

- ruptures of overload signalling systems (if present);
- presence of adequate slack (in dynamic systems);
- status of the shock-absorber (if used);

- absence of slack or other signs of loosening of the system (in static systems);
- degree of ingrowth;
- current status of the secured biomechanical feature;
- in dynamic systems: confirmation that the end of the splice is still visible, including rope allowance for loosening the system to accommodate tree growth (no tension in the system, increment loop present, etc.);
- acute angle of rope entering the splice (if applicable).

5.4 Detailed inspection

5.4.1 Detailed inspection of the stabilisation system is performed according to the manufacturer's instructions, at least once every 5 years (or based on instructions given by the installer and/or inspector, whichever interval is shorter). In addition, detailed inspection can be performed on demand, if there are observed concerns.

5.4.2 Detailed inspection comprises a close aerial examination of the system in situ.

5.4.3 Detailed inspection includes checking the parameters listed in 5.3.4 and adjusting (repositioning) or loosening parts of the stabilisation system, if necessary, to accommodate tree growth.

5.4.4 Detailed inspection does not include replacement of a stabilisation system or its parts.

5.4.5 It is advisable to combine detailed inspection of tree stabilisation systems with any on-going crown maintenance (pruning etc.) according to the specification in the tree management plan.

5.4.6 Detailed inspection should include taking photographs of the main load-bearing elements of the stabilisation system.

5.5 Replacement

5.5.1 Cabling systems must be replaced:
- after reaching their maximum service life as defined by the manufacturer;
- if there is damage to load-bearing parts;
- if the tree's structural condition has changed significantly;
- after failure of a significant part of the tree;
- after overload of the cabling system (some models include an overload signalling system, e.g. a coloured thread with a lower breaking strength).

5.5.2 In the case of replacement, the same approach should be taken as with a new installation, including an overall tree assessment.

5.5.3 If a stabilisation system is being removed that has become ingrown into the tree, ensure that the tree is not damaged by removing these parts.

5.5.4 If replacement of a dynamic system with slack (not under tension) is required, it should be carried out in the following order:
- tree pruning, if necessary;
- install the new system;
- remove the old system.

5.5.5 If replacement of a dynamic system under tension is required, after evaluation of the changed load distribution, it should be carried out in the following order:
- tree pruning, if necessary;
- install a backup system (temporary preloaded static connection);
- remove the old system;
- slowly release the backup system with careful check of the movement of the defect;
- install the new system.

5.5.6 If a dynamic system must be replaced with static system, it should be carried out in the following order:

- tree pruning, if necessary;
- install a backup system (if under tension);
- install the new static system;
- remove the old (dynamic) system;
- release the backup system.

5.5.7 If replacement of a static system is required, it should be carried out in the following order:

- measure the tension on the cable to be replaced with a tensiometer in order to choose the right replacement system and to find out the force required to remove the existing one;
- tree pruning, if necessary;
- decide if an additional dynamic system is needed (even if it is temporary) to reduce indirect effects (concentration of mechanical stress at new points);
- install a backup system;
- install the new static system. When tensioned cables are replaced, they should be as close as possible to the original, both in terms of their positions in tree and the tension exerted. A sudden change in tree biomechanics can lead to new stresses and an increase, at least temporarily, in the probability of failure;
- remove the old system;
- release the backup system.

5.5.8 It is not recommended to replace or install additional tree stabilisation systems without removing the old ones, unless you are targeting a new (emerging) biomechanical weakness on the tree.

6. Site management

6.1 Introduction

6.1.1 Tree stabilisation is a highly specialised operation that must be properly planned and performed and regularly monitored. This chapter covers the additional considerations of tree stabilisation, which can affect the surroundings and neighbouring individual trees.

6.2 Impact on soils

6.2.1 During tree stabilisation works, the impact on soil quality, which is essential for tree health, must be considered throughout the whole operation, including management of arisings.

6.2.2 Soil compaction and soil degradation must be avoided, or mitigated if they cannot be avoided.

6.2.3 To avoid soil compaction and degradation, carefully plan the following:
- access on and off the work site;
- location of fuelling station (if applicable);
- parking/positioning of equipment (truck, trailer etc.) and particularly MEWP positioning, if appropriate.

6.2.4 Avoiding soil compaction and degradation might require changing the timing of operations (e.g. to outside of the wet season) or the work plan (e.g. type of MEWP used).

6.3 Impact on neighbouring trees

6.3.1 When any tree work is planned, the impact on neighbouring trees must be considered. Other trees should not be negatively affected by stabilisation measures, e.g. by an unacceptable change in the wind load distribution.

6.3.2 This effect must be considered especially in cases where surrounding trees are used to stabilize the tree in question, or when stabilisation systems with underground foundations (e.g. props) are installed.

6.3.3 If the impact on neighbouring trees cannot be avoided, mitigation measures must be put in place.

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ABBREVIATIONS

CE	Conformité Européenne (administrative marking that indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area)
EAC	European Arboricultural Council
EAS	European Arboricultural Standards
EN	European Standards
ETT	European Tree Technician
ETW	European Tree Worker
EU	European Union
GDPR	General Data Protection Regulation
ISA	International Society of Arboriculture
MEWP	Mobile Elevating Work Platform
PPE	Personal Protective Equipment
TeST	Technical Standards in Treework
VETcert	Veteran Tree Certification program

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