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Lesnická a dřevařská fakulta Mendelova univerzita v Brně

NATURE AND LANDSCAPE MANAGEMENT STANDARDS

ARBORIST STANDARDS	**CROWN SECURITY SYSTEMS (CABLING / BRACING)**	**SPPK A02 004:2019**
SERIES A		

Bezpečnostní vazby a ostatní stabilizační systémy

Kronensicherungssystemen

This standard is intended as a definition of model technical and technological procedures for installation of crown security systems (cabling and bracing) under specific conditions of non-forest trees.

References (selection):

ČSN EN 15567-1: Sports and recreation equipment – Chairlifts – Part 1: Design and safety requirements.
ČSN EN 15567-2: Sports and recreation equipment – Chairlifts – Part 2: Functional requirements.
ČSN EN 12385-1 +A1 (024302): Steel wire cables – Safety – Part 1: General requirements.
ČSN EN 12385-2 +A1 (024302): Steel wire cables – Safety – Part 2: Definitions, identification and classification.
ČSN EN 12385-3+A1 Steel wire cables – Safety – Part 3: Information for use and maintenance.
ČSN EN 12385-4+A1: Steel wire cables – Safety – Part 4: Stranded cables for general lifting purposes.
ČSN 02 4460: Six-stranded steel cables – Production.
ČSN 02 4468: Steel cables. Making of loops on steel cables.
ČSN 02 4490: Light thimbles for steel cables.
ČSN EN 13411-1+A1: Termination of steel wire cables – Safety – Part 1: Sockets for slinging devices made of steel wire cables.
ČSN EN 13411-2+A1: Termination of steel wire cables – Safety – Part 2: Steel cable twisted loops for slinging devices.
ČSN EN 13411-3+A1: Termination of steel wire cables – Safety – Part 3: Bushings and secured bushings.
ČSN EN 13411-4: Termination of steel wire cables – Safety – Part 4: Embedding in metal and resin.
ČSN EN 13411-5+A1: Termination of steel wire cables – Safety – Part 5: Shackles for termination of wire cables.
ČSN EN 13411-6+A1: Termination of steel wire cables – Safety – Part 6: Asymmetric wedge fork bushings.
ČSN EN 13411-7+A1: Termination of steel wire cables – Safety – Part 7: Symmetric wedge fork bushings.
ČSN EN 13414-1+A2: Slinging devices made of steel wire cables – Safety – Part 1: Slinging devices for general lifting work.
ČSN EN 13414-2+A2: Slinging devices made of steel wire cables – Safety – Part 2: Information for use and maintenance provided by the manufacturer.
ČSN EN 13414-3+A1: Slinging devices made of steel wire cables – Safety – Part 3: Cable loops and slinging devices made from twisted cables.
ČSN EN ISO 9554: Textile ropes – General specifications.
ČSN EN ISO 2307: Textile ropes – Determination of certain physical and mechanical properties.
ČSN EN ISO 1140: Textile ropes – Polyamide – 3-, 4-, 8- and 12-strand ropes.

ČSN EN ISO 1141: Textile ropes – Polyester – 3-, 4-, 8- and 12-strand ropes.
ČSN EN ISO 1346: Textile ropes – 3-, 4-, 8- and 12-strand ropes made of polypropylene split bands, monofilaments and and multifilaments (PP2) and high-strength polypropylene multifilaments (PP3).
ČSN EN ISO 1181: Manila hemp and sisal – 3-, 4- and 8-strand ropes.
ČSN EN ISO 1968: Textile ropes and ropemaking products – Glossary of terms.
ČSN EN ISO 1969: Textile ropes – Polyethylene – 3- and 4-strand ropes.
ČSN EN ISO 10325: Textile ropes – High-molecular polyethylene – 8-stranded twisted ropes, 12-stranded twisted ropes and coated ropes.

Government Regulation no. 339/2017 Coll., on detailed requirements on work and work procedure organisation methods in forest work and workplaces of similar nature.
Government Regulation no. 362/2005 Coll., on detailed requirements on occupational health and safety in workplaces with a risk of fall from a height or into a depth.
Government Regulation no. 591/2006 Coll., on detailed minimum requirements on occupational health and safety in workplaces, as amended.
Decree no. 189/2013 Coll. on Tree Protection and Felling Permission, as amended.
Act no. 36/1967 Coll. on Experts and Interpreters, as amended.
Act no. 89/2012 Coll., the Civil Code, as amended.
Act no. 114/1992 Coll. on Nature and Landscape Protection, as amended.

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1 Purpose and contents of the standard

The standard "Crown security systems (cabling / bracing)" defines work procedures associated with technical stabilisation of non-forest trees, installation of safety bonds, cabling and bracing.

Installation of crown security systems is made in justified cases on significantly destabilised trees in order to extend their outlook and improve their operating safety.

1.1 Legal framework

1.1.1 Pursuant to **Act no. 89/2012 Coll.** (the Civil Code), more specifically the general preventive obligation defined in Section 2900, a tree owner is required to ensure operating safety of trees, including the obligation to make adequate stabilising interventions and inspections of stabilisation systems installed.

1.1.2 Pursuant to **Act no. 114/1992 Coll.**, management of trees in non-forest environments is the owner's obligation (Section 7, Para. 2).

1.2 Qualifications of persons

1.2.1 Design of interventions connected with tree stabilisation is an expert activity done by qualified persons, who may include:

- judicial experts under Act no. 36/1967 Coll. with a specialisation including tree assessment or similar, or
- graduates from study programmes and specialisations of faculties or tertiary professional schools of forestry, horticulture, scientific, environmental, etc., where tree assessment issues are taught, or
- holders of a national or international proof of expert knowledge in the area[1].

1.2.2 The recommended qualification for persons doing **installation of security systems at heights** is a recognized national or international proof of the worker's expert knowledge and skills in the area of arboriculture[2].

[1] For example, Czech Certified Arborist – Consultant, European Tree Technician, etc.

[2] For example, European Treeworker, ISA Certified Tree Worker Climber Specialist, Czech Certified Arborist – Tree Climber, Arboriculture Technician, etc.

2 Tree stabilisation options

2.0.1 A tree stabilisation design is based on an assessment of the individual's outlook and related functional, composition and economic context. The objective is to assure an acceptable degree of risk associated with the existence of structurally compromised trees.

2.0.2 It is recommended to only design and install stabilisation systems in justified cases on destabilised trees for which an adequate inspection and follow-up management regime can be provided.

2.0.3 Crown security systems are applied primarily where it is impossible to achieve an adequate degree of stabilisation by pruning and where it is not appropriate to consider removal of the destabilised tree.

2.0.4 Assessment of structurally significant defects and their effect on tree stability is made pursuant to SPPK A01 001 Tree assessment. Decision on the type of adequate stabilisation intervention is made following points 2.0.5 to 2.0.8 below. In case this procedure cannot achieve adequate operating safety, the design and installation of a stabilisation system are considered.

2.0.5 If satisfactory tree stabilisation is impossible due to colliding requirements for provision of site operating safety and requirements for retaining the trees, a **felling** can be regarded as the more appropriate procedure. The felling shall respect SPPK A02 005 Tree felling.

2.0.6 Site operating safety can be modified by **modification of the fall target area**, that is, reduction to pedestrian or vehicular traffic frequency (or its elimination) within the tree impact distance (double the tree height) or removal of threatened objects from the area.

2.0.7 Stabilisation of parts of tree crowns can be made using **local reductions** (S-RLLR) pursuant to SPPK A02 002 Tree pruning.

2.0.8 Stabilisation of an entire tree can be made using **stabilisation pruning** (S-RO, S-SSK, S-RS) pursuant to SPPK A02 002 Tree pruning.

2.0.9 Stabilisation systems are divided into the following types:

- dynamic bonds (preventive[3]),
- static bonds (biomechanically necessary[4]),
- cabling,
- bracing.

2.0.10 In most cases, installation of stabilisation systems can be conveniently combined with other tree stabilisation procedures.

2.0.11 It is advisable to combine the stabilisation procedures in order to achieve the maximum effect with minimised intervention in the trees.

2.0.12 The stabilisation system type, its sizing and installation method have to correspond primarily to the defect being stabilised, the tree taxon and size in relation to the site where the tree is located.

[3] Preventive = intended to prevent a part of the tree crown falling on the ground in the case of failure, i.e., material damage or detriment to health or life.

[4] Biomechanically necessary = intended to help retain current situation of the individual.

2.0.13 An inappropriately chosen stabilisation system may lead to a negative effect on stability of the whole tree: notably, its resistance to windthrow or failure of some of the secured branches.

2.1 Stabilisation system design

2.1.1 A design shall mandatorily contain the following items:

- clear tree identification,
- bond type (dynamic/static),
- specific type of static bond (e.g., padded/drilled),
- installation level (upper/lower level),
- number of bonds (ropes, braces, cabling),
- minimum required carrying capacity throughout the bond service life.

2.1.2 In the case of trees with existing stabilisation systems installed, the treatment technique design shall include an inspection regime.

2.1.3 Recommended codes for designing stabilisation system types are as follows:

- S-VDH – dynamic bond at the upper level,
- S-VDD – dynamic bond at the lower level,
- S-VSV – static bond, drilled,
- S-VSP – static bond, padded,
- S-VO – cabling installation,
- S-VP – brace installation,
- S-VK – inspection of existing installed stabilisation system.

Other items arising from 2.1.1 are listed in the technique remarks. For inspection of existing installed stabilisation systems, the system has to be specified in the remarks analogously to 2.1.1.

2.1.4 A design for treatment of a stabilised tree typically contains additional interventions, arising notably from:

- SPPK A02 002 Tree pruning,
- SPPK A02 009 Special tree treatment.

2.2 Dynamic bonds

2.2.1 Dynamic bonds refers to a type of bonds that are installed as preventive, made from dynamic extensible ropes with declared resistance to climate effects.

2.2.2 Bond system types shown in Annex 1 are recommended for use in the Czech Republic.

2.2.3 The load-bearing elements of an installed system (each bond) have to be composed exclusively of components from a single manufacturer, of a single type and single carrying capacity. Combinations of bond elements are prohibited, except cases permitted by the system manufacturer.

2.2.4 Dynamic bonds must not be installed as pre-tensioned[5].

2.2.5 Cables in the crown must not become taut in the calm condition throughout their service life. That has to be reflected by cable loosening during installation and an adequate cable allowance in a so-called increment loop or located loosely past the splice.

2.2.6 The load-bearing cable must not be in unprotected contact with any branch or any

[5] In pre-tensioned bonds, the tensile force is transmitted to those parts of the crown that are statically stabilised.

other object in the crown (e.g., another cable, brace, etc.). Branch movements in the wind have to be considered and risk of contact and abrasion of the load-bearing cable eliminated.

2.2.7 The distance of the cable splice, or trunk bushing and cable connection, during installation is at least equal to half the diameter of the trunk or branch being secured at the point of installation (see Annex 2, Figure 1). The angle of the trunk bushing or cable leading towards the splice has to be acute, no more than approx. 60° at the time of installation.

2.2.8 The splice loop has to be protected around the trunk with a suitable bushing (sleeve), which has to extend to the splice.

2.2.9 The cable splice shall be made according to system manufacturer instructions or in accordance with ČSN EN standards in force.

2.2.10 The system location and sizing is handled in 2.6.

2.3 Static bonds

2.3.1 Static bonds (biomechanically necessary) refers to such bods that are made of structural materials with minimum extensibility. They are installed as pre-tensioned.

2.3.2 The recommended static bond types are:

- drilled bond,
- padded bond.

2.3.3 Other types are not suitable due to increased risk of trunk strangulation.

2.3.4 The load-bearing components have to be made an appropriate structural steel or material with similar strength parameters and resistance for the required system carrying capacity.

2.3.5 The material and strength of the components used for a static bond have to be declared in the handover report for the installed bond. The report is a mandatory part of the documentation that is handed over to the tree owner along with the installed bond.

2.3.6 Cables must not touch each other (for example, as “figure eights” in the case of padded bond installation).

2.3.7 The load-bearing cable must not be in unprotected contact with any branch or any other object in the crown to prevent their damage.

2.3.8 The system location and sizing is handled in 2.6.

2.3.9 A **drilled bond** is typically made up of the following components:

- steel rods installed in a hole drilled through the trunk or branch,
- washer at least 50 mm in diameter,
- nut,
- thimble,
- eye nut,
- connecting system,
- steel cable or heavy-duty rod.

Use of other components or systems is possible if not more destructive for the tree than the above system and if the contractor documents the required carrying

capacity.

2.3.10 A **padded bond** is composed of::

- load-bearing static cable encircling the trunk or branch to be secured,
- connecting system (or splice),
- pads (2.6.16 – 2.6.22).

2.3.11 The recommended methods of installation of a padded bond are:

- endless loop (Annex 2, Figure 7),
- "figure eight" (Annex 2, Figure 8).

2.4 Cabling

2.4.1 Cabling is a trunk stabilisation system that is only installed exceptionally in particularly justified cases where no other method of stabilisation is feasible.

2.4.2 Cabling needs to be installed on pads (see 2.6.16 to 2.6.22) to reduce the negative effect of ingrowing.

2.4.3 Old cabling becomes an integral part of the stabilised tree. It cannot be removed without prior installation of a new static stabilisation system.

2.4.4 If old cabling cannot be removed without damaging the tree, it is advisable to disconnect them to prevent further strangulation of the trunk. Ingrown parts can be left in the trunk.

2.5 Tree braces

2.5.1 This is a system that can increase the stability of an entire tree or its parts in case no other adequate stabilisation method can be used. It is mostly advisable to combine braces with other types of stabilisation interventions.

2.5.2 Installed braces become an integral part of the stabilised tree. Their removal without substitution is out of the question.

2.5.3 Braces can be installed as static, which support a specific part of the tree directly, or as dynamic (typically containing springs), which only unweight parts of the tree and prevent extreme swaying.

2.5.4 The basic requirements for bracing are:

- sufficient carrying capacity and stability of load-bearing elements,
- ability of the brace to effectively transmit forces occurring,
- consideration for other parts, particularly at the fastening points,
- resistance to weather effects.

2.5.5 Foundations for fastening braces have to be made carefully to minimised damage to the tree's roots. All excavation work shall respect SPPK A01 002 Protection of woody plants during development activities.

2.5.6 Brace design has to consider specific features of the individual's properties and its surroundings. Aesthetic requirements are taken into consideration.

2.5.7 It is advisable to use A-shaped or rectangular brace installation (Annex 2, Figure 9).

2.5.8 Installed braces require periodic inspection and maintenance focused notably on the condition of the securing and secured elements, paying attention to the extent of ingrowth into living tissues.

2.6 Bond sizing and location

2.6.1 By default, bonds are installed at one level; in case the required stabilisation effect cannot be achieved, they can be installed at multiple levels.

2.6.2 It is advisable to consider multilevel security bonds in the following cases:

- combination of static and dynamic bonds particularly in trees with a high centre of gravity,
- stabilisation of high-branching trees or long horizontal branches,
- stabilisation of branches and trunks immediately over the fall target.

2.6.3 The length of branch-stabilising bonds and their location have to be chosen so that the fall target is not hit in case the secured part breaks off.

2.6.4 Bond sizing has to consider additional parameters of the secured parts of the crown, particularly:

- length of secured branch (height of centre of gravity),
- cable angle,
- own weight of the secured part of the crown,
- for static bonds, degree of bond pre-stressing at installation.

2.6.5 **Static bonds** are sized as a system to carry and secure parts of the crown. The carrying capacity of a static bond is expressed as the minimum required carrying capacity throughout its service life. They can be sized according to the following informative table based on the diameter of the secured branch:

Secured branch or trunk diameter (measured at the time of installation past the branching collar or at the branching point of the secured trunk)	**Minimum system carrying capacity**[6]	**Recommended bond type**
up to 300 mm	20 kN	drilled
300 – 400 mm	30 kN	drilled
400 – 600 mm	40 kN	drilled, padded
600 mm or more	80 kN	padded

2.6.6 Static bonds are usually composed using high-performance rolled steel cables or conventional design steel cables with corrosion-resistant surface finish (e.g., galvanised, hot galvanised, etc.). Cable diameter and sizes of other load-bearing system elements depend on the required carrying capacity (see Annex 3).

2.6.7 Static bonds are installed exclusively in the lower half of the secured part of the tree (counted from the secured defect – branching point – to the crown apex). For multilevel bonds, the upper level of the static bond is installed no higher than at one half of the secured part of the tree (Annex 2, Figure 2).

2.6.8 Alternatively, static bonds are installed as:

- drilled bonds (2.6.9 to 2.6.15),
- padded bonds (2.6.16 to 2.6.22).

2.6.9 For **drilled bonds**, the secured trunk or branch should typically not be more than 600 mm in diameter at the point of installation.

[6] Bond carrying capacity is quoted in t or kN, where 1 t corresponds to 10 kN.

2.6.10 Places for the drilled holes must not show symptoms of infection by wood-decaying fungi. If in doubt, it is advisable to check the place for the drilled hole with an appropriate instrumental test (see SPPK A01 001 Tree assessment).

2.6.11 It is advisable not to drill holes through the branch cone.

2.6.12 The vertical distance between drilled holes in the same branch (steel rod eyes) at the place of drilled bond installation should not be more than 500 mm.

2.6.13 The rod should run through the trunk axis.

2.6.14 One eye may hold no more than two cables as needed so that their mutual angle is no more than 60°. If this requirement is failed, a calculation has to verify the carrying capacity of the whole system as designed.

2.6.15 If the secured branches are close together at the bond installation point, the drilled bond can be installed using a single rod running through both trunks.

2.6.16 A **padded bond** has to be pre-tensioned so as to prevent movement of pads and their falling out when strained even with strong wind.

2.6.17 The pads have to be installed so that the distance between the cable and the surface of the secured trunk or branch is not less than 20 mm at any point.

2.6.18 The pads act as protection of the secured part from mechanical damage and ingrowth, so they have to be made of hardwood (such as oak, ash, locust) or a material of analogous quality. The wood has to be well processed with a smooth surface. It is advisable to prime the wood with primer coats to increase its service life.

2.6.19 The width of each pad is 50 to 100 mm, its length is 100 to 300 mm. The pad height is such to satisfy the requirement of 2.6.17.

2.6.20 The distance between pads has to correspond at least the width of one pad.

2.6.21 Pad shape and finish have to prevent cable sliding and falling out.

2.6.22 At least two edge pads on each secured trunk or branch have to be solidly fastened to the trunk, e.g., with screws, to prevent falling out. Fastening all the pads is recommended.

2.6.23 **Dynamic bonds** are sized to capture shocks from dynamic crown movements. The carrying capacity of a dynamic bond is expressed as the minimum required carrying capacity throughout its service life. They are sized based on the diameter of the secured branch as follows:

Secured branch diameter (measured at the time of installation past the branching collar or at the branching point of the secured trunk)	**Minimum system carrying capacity**	**Maximum system carrying capacity**
up to 400 mm	20 kN	40 kN
400 – 600 mm	40 kN	80 kN
600 mm or more	80 kN or more	no restriction

2.6.24 Dynamic bonds are installed exclusively in the upper half of the secured part of the tree (counted from the secured defect – branching point – to the crown apex). The optimum installation height is at 2/3 of the distance (Annex 2, Figure 2). For multilevel bonds, the lower level of the dynamic bond can typically be located at one half of the secured part of the tree, or lower in justified cases.

2.6.25 It is advisable not to installed the trunk bushings of dynamic bonds in narrow branching points, where they are likely to become ingrown.

2.6.26 Trunk bushings have to be suitably fastened at a height, typically to a side shoot.

2.6.27 Bonds can be installed in the crown in the following geometries (and their combinations):

- direct bond mutually stabilising two branches/trunks,
- triangle bond,
- circumference bond of multiple trunks.

2.6.28 **Direct bonds** are used to capture overloading of secured parts only in the installation direction. It cannot capture lateral strains. If possible, use of other parts of the crown in two directions is recommended (Annex 2, Figure 3).

2.6.29 **Triangle bonds** are very stable bonds that make it possible to capture overloading of secured parts of the crown in multiple strain directions (Annex 2, Figure 4).

2.6.30 **Circumference bonds** of multiple trunks capture only strains acting along the axes of the installed bonds. They are frequently used for temporary stabilisation of secondary crowns or as a combination in multilevel bonds (Annex 2, Figure 5).

2.6.31 **Special types of installation** of security bonds are as follows:

- branch base stabilisation,
- crown apex stabilisation,
- mutual stabilisation of multiple trees.

2.6.32 **Branch base stabilisation** to prevent fall target impact is made using two cables (bonds), one of which fastens the branch at approximately 2/3 of its length and another at its base (Annex 2, Figure 6). Dynamic bonds are used for these purposes notably.

2.6.33 **Crown apex stabilisation** can be designed notably for slender trees with a high centre of gravity with a risk of crown apex failure as a consequence of dynamic strain. The stabilisation is achieved by installation of a dynamic bond in the vertical direction with fastening:

- of the apex above the expected failure location,
- at a point that enables reliable retention of a potential fall.

2.6.34 The bond has to be sized to capture and retain the secured part of the crown, that is, according to 2.6.23.

2.6.35 The length of the bond and its location have to be chosen so that the fall target is not hit in case the secured apex breaks off.

2.6.36 **Mutual stabilisation of multiple trees** can be designed and made only in exceptional cases and requires an examination of stability of the securing trees.

3 Installation of stabilisation systems

3.1 Workplace security

3.1.1 Workplace security when installing tree crown stabilisation systems has to comply with Government Regulation no. 591/2006 Coll.

3.1.2 The minimum danger area is defined in accordance with Government Regulation no. 362/2005 Coll. at a minimum distance of:

a) 1.5 m when working at a height of 3 m to 10 m,
b) 2 m when working at a height of 10 m to 20 m,
c) 2.5 m when working at a height of 20 m to 30 m,
d) 1/10 of the tree height when working above 30 m.

The width of the danger area is delineated from the foot of the vertical line passing through the outer edge of the crown projection of the secured tree, unless the work procedure specifies otherwise based on a risk analysis.

3.2 Jointing of steel cables

3.2.1 Jointing of steel cables for static bonds can be alternatively made of the following components:

- wire cable clamps with corrosion-prevention finish,
- cable splicing,
- splicing wire,
- strong compression, etc.

3.2.2 When using wire cable clamps, the following procedure has to be observed:

- determine the suitable clamp size based on cable diameter,
- visual inspection of the clamp (cracks, shape defects, etc.),
- determining of the adequate length of the unstressed end of the cable with respect to the prescribed number of clamps (see 3.3.3) for the joint,
- the clamp has to be fastened so that its shackle encircles the unstressed (loose) end of the cable and its base carries the stressed cable (see Annex 2, Figure 10),
- the cable end has to be secured against unbraiding,
- the clamp farthest from the thimble is installed first,
- the cable has to be slightly pre-tensioned before installing the second clamp to prevent cable crumpling between the clamps,
- the clamp just behind the thimble is installed next, then other clamps between the first and the second one,
- distance between clamps is 1.5 to 3 times the width of the clamp bridge,
- clamps are tightened gradually, alternating the two nuts, to the prescribed tightening torque,
- when connecting two independent continuous ropes (e.g., in a padded bond) the number of clamps used is double the recommendation for the cable size,

- after bond pre-tensioning, recheck tightening of clamps to the prescribed torque,
- minimum length of loose (stressed) cable between outer clamps of each end is 30 times the cable diameter.
- minimum length of loose (unstressed) cable past the last clamp is 10 times the cable diameter.

3.2.3 The minimum numbers of clamps:

- 2 for cables 5-7 mm in diameter,
- 3 for cables 8-17 mm in diameter,
- 4 for cables 18-23 mm in diameter,
- 5 for cables 24-27 mm in diameter.

3.3 Jointing of synthetic ropes

3.3.1 Synthetic ropes are used typically for dynamic bonds. The exception is ropes made of high-performance synthetic materials (Dyneema, Vektran, etc.) used for certain types of static bonds.

3.3.2 Installation of dynamic bonds shall always follow the technical data sheet or instructions for use for the given type.

3.3.3 When using separate synthetic ropes without instructions for use, the splicing shall be in accordance with ČSN EN.

3.3.4 During installation, a sufficient rope allowance has to be left past the splice (300-600 mm depending on expected tree increment), either hanging loosely or in the form of an increment loop to enable loosening of the bond during inspections.

3.3.5 The following types of splicing are typically used (or other options as per ČSN EN in force):

- conventional splice,
- conventional splice with two piercings,
- pierced splice with threading,
- pierced splice.

3.3.6 **Conventional splice** – 250-600 mm of rope is run through the inside of the hollow rope in the opposite direction. The splice length always depends on the diameter of the rope used. This splice is mostly used in polypropylene ropes, but can be used in polyester ropes as well.

3.3.7 **Conventional splice with two piercings** – two piercings are made through the whole rope approx. 50 mm apart at the start of the splice. Then, 200-400 mm of rope is run through the inside of the hollow rope in the opposite direction. This splice type is mostly used in polyester ropes.

3.3.8 **Pierced splice with threading** – 4-5 piercings are made approx. 50 mm apart at the start of the splice and eventually at least 150-200 mm of rope is run through the inside of the hollow rope in the opposite direction. This splice type is mostly used in polyester ropes.

3.3.9 **Pierced splice** – 4-5 piercings between the rope strands are made approx. 50 mm apart at the start of the splice. The end of the rope is left pulled out. This splice type

is used mainly in ropes made of high-performance synthetic materials.

3.4 Records on stabilisation systems

3.4.1 To facilitate periodic inspection of stabilisation systems and monitor their maximum service life, physical identification of the bond installation year on non-loaded bond elements is recommended (e.g., with a date tag, writing in permanent paint, etc.).

3.4.2 After the system installation, information about it has to be entered in the client's information system or a generally accessible information system.

3.4.3 Records on stabilisation systems include the following information:

- installation date,
- proposed inspection date,
- stabilisation system type (dynamic, static, cabling, bracing),
- installation level,
- type and model of bond installed,
- bond carrying capacity,
- number of ropes (braces).

3.4.4 The records shall also include contact details for the arborist installing the system.

3.4.5 It is advisable for the information system to enable records on routine and inspection checks and appropriately ensure transfer of information about the end of the service life of the stabilisation system.

4 Contractor-client relationships

4.1 Handover of installed stabilisation systems

4.1.1 A stabilisation system is accepted based on a handover report by the implementing company (in written or electronic form), containing at least information under 3.4.3. The handover report for static bonds additionally contains information under 2.3.5.

4.1.2 The stabilisation system handover includes definition of follow-up management, if different from provisions of chapter 5 herein.

4.2 Warranties

4.2.1 The person (legal entity) making the stabilisation system installation design is liable for optimal choice of stabilisation system type and sizing.

4.2.2 The person (legal entity) doing the stabilisation system installation is liable for the overall performance, i.e., correct installation technique, correct bond type and adequate securing of all destabilised parts of the tree crown. If the stabilisation system design is wrong (see 4.2.1), the person/entity should inform the client about it and should not perform installation according to the wrong project design.

5 Inspections and checks of stabilisation systems

5.0.1 Tress with installed stabilisation systems have to be inspected periodically.

5.1 Routine check

5.1.1 A routine check is made once every 12 months and after extreme climate events using visual examination methods.

5.1.2 The check is made from the ground, without ascending to the crown.

5.1.3 The optimum time for the routine check is outside the growing season. Performing the check at a different time is not a process error.

5.1.4 Notably the following parameters are checked:

- degree of damage of security systems,
- tightness (dynamic bonds),
- looseness (static bonds),
- degree of ingrowth,
- condition of the secured defect,
- in dynamic bonds, visibility of end of splice, including rope allowance for loosening (hanging loosely, increment loop, etc.),
- acute angle of rope entering the splice.

5.2 Inspection check

5.2.1 An inspection check is made according to manufacturer instructions (see Annex 1) at least once every 48 months using climbing equipment and detailed examination of the bond at its point of installation.

5.2.2 It involves a detailed inspection of the stabilisation system to the extent of a routine check, shifting or loosening it as necessary.

5.2.3 An inspection check does not include reinstallation of a stabilisation system or its parts.

5.2.4 It is advisable to combine security bond inspection with repeated maintenance or stabilisation pruning according to the definition in the tree treatment design.

5.2.5 An inspection check includes photo documentation depicting the main load-bearing elements of the stabilisation system.

5.3 Inspection outcomes

5.3.1 The outcome from both types of inspection (5.1 and 5.2) is a report (in writing or in electronic form) recording the following:

- inspection date,
- person in charge making the inspection,
- inspection results,
- any recommended remedial measures.

5.3.2 Inspection reports need to be archived throughout the bond service life.

5.4 Procedures for stabilisation system replacement

5.4.1 Stabilisation system replacement is made in case the system:

- does not perform its function,
- is past the service life set by the manufacturer,
- comes from an unknown manufacturer or cannot be identified,
- cannot be demonstrably identified as to its real age,
- is damaged, wrongly or inappropriately installed, undersized,
- negative affects tree growth or damages the tree,
- if the tree condition has changed.

5.4.2 When reinstalling a bond, the procedure is the same as for installation of a new bond (see chapter 3). It is always necessary to assess the current condition of the tree, choose the appropriate bond type and carrying capacity and design appropriate pruning as needed.

5.4.3 A bond cannot be removed without subsequent appropriate securing with a new bond or stabilisation pruning. When removing old ingrown bonds, the tree damage in the ingrowth point must not be worsened. It is not advisable to mechanically remove ingrown bonds.

5.4.4 Procedure for replacement of a functional **dynamic bond at the end of its service life**:

- appropriate pruning is done as needed,
- the old bond is removed and a new one is installed depending on the existing and required securing (appropriate carrying capacity and number of cables).

5.4.5 Procedure for **reinstallation of a taut dynamic bond instead of a dynamic bond**:

- adequate tree reduction as needed,
- branch securing with a suitable device to prevent oscillation,
- removal of old bond,
- loosening the oscillation securing,
- installation of a new dynamic bond.

5.4.6 Procedure for **reinstallation of a taut dynamic bond instead of a static bond**:

- adequate tree reduction as needed,
- branch securing with a suitable device to prevent oscillation,
- installation of a static bond of a suitable type and carrying capacity,
- removal of old bond,
- loosening the oscillation securing,
- installation of a new additional dynamic bond as necessary.

5.4.7 Procedure for **reinstallation of static bonds**:

- appropriate pruning as needed,
- installation of a suitable new static bond with adequate carrying capacity near the existing bond,
- removal of old bond once the load is transmitted to the new bond.

5.4.8 Following any bond reinstallation, the installed system has to be handed over properly according to 4.1.

Annex 1 Commonly used bond systems

Type	Manufacturer	Carrying capacity [t]	Material	Cable diameter [mm]	Extensibility [%]	Cable carrying capacity at installation [kN]	Declared system carrying capacity [kN]	Splice type	Installation instructions available	Recommended service life on tree	Expected carrying capacity reduction/year [%]	System carrying capacity at end of service life [kN]	Recommended check interval (from ground) [years]	Recommended inspection interval (climbing) [years]	Components
Arbo Line 2	Gleistein Ropes	2	polyester	28		45	45	knotless splice into cable hollow	NO	-	-	-	-	-	cable/trunk strap/protective sleeve
Arbo Line 4		4	polyester	45		82	82	knotless splice into cable hollow	NO	-	-	-	-	-	cable/trunk strap/protective sleeve
Arbo Line 8		8	dyneema	12		115	-	knotless splice into cable hollow	NO	-	-	-	-	-	cable/trunk strap/protective sleeve
Gemini S 7/28		4,5	polyester	28	2.2[1]/9.6[2]	45	45	knotless splice into cable hollow	NO	8	7	25	1	3	cable/protective sleeve
Gemini S 10/28		8,2	polyester	45	2.2[1]/9.6[2]	82	82	knotless splice into cable hollow	NO	8	7	45	1	3	cable/protective sleeve

Arco Standard 2	Arboristická obchodní, s.r.o.	2	polypropylene monofil	14	17	34,5	30	knotless splice into cable hollow - conventional splice without piercing 45 cm long	YES	12	2	26 after 15 years	1	4	cable/trunk bushing
Arco Plus 4		4	polypropylene monofil	18	14,6	52.95	50	knotless splice into cable hollow - conventional splice without piercing 45 cm long	YES	12	2	39.9 after 15 years	1	4	cable/trunk bushing

[1] When loaded to 10% of carrying capacity; [2]When loaded to 50% of carrying capacity.

Type	Manufacturer	Carrying capacity [t]	Material	Cable diameter [mm]	Extensibility [%]	Cable carrying capacity at installation [kN]	Declared system carrying capacity [kN]	Splice type	Installation instructions available	Recommended service life on tree	Expected carrying capacity reduction/year [%]	System carrying capacity at end of service life [kN]	Recommended check interval (from ground) [years]	Recommended inspection interval (climbing) [years]	Components
Boa 2	arboa e.K. tree safety	2	polypropylene monofil	15	17	34,8	34,8	knotless splice into cable hollow	YES	12	approx. 3.5	min. 20	1-3	1-3	colour code – disk/wide strap/protective sleeve/shock absorber/special sliding tape
Boa 4		4	polypropylene monofil	25	17	52	52	knotless splice into cable hollow	YES	12	approx. 1.9	min. 40	1-3	1-3	colour code – disk/wide strap/protective sleeve/shock absorber/special sliding tape
Boa 8		8	polyester	30	approx. 17	114,06	114,06	knotless splice into cable hollow	YES	12	approx. 2.5	min. 80	1-3	1-3	colour code – disk/wide strap/protective sleeve/shock absorber/special sliding tape
Boa Silver		8	dyneema multifil	10	2	99	90	knotless splice into cable hollow	YES	8	-	min. 40	1-3	1-3	Dyneema loops: S120 cm/M160 cm/L 200 cm

Type	Manufacturer	Carrying capacity [t]	Material	Cable diameter [mm]	Extensibility [%]	Cable carrying capacity at installation [kN]	Declared system carrying capacity [kN]	Splice type	Installation instructions available	Recommended service life on tree	Expected carrying capacity reduction/year [%]	System carrying capacity at end of service life [kN]	Recommended check interval (from ground) [years]	Recommended inspection interval (climbing) [years]	Components
Cobra 2t	pbs Baumsicherungsprodukte GmbH	2	polypropylene	14	17	34,5	30,3	knotless splice into cable hollow ≥ 40 cm	YES	12	2-3	min. 20	2	4	cable/cap/wide strap/protective sleeve/shock absorber
Cobra 4t		4	polypropylene	18	17	53	48	knotless splice into cable hollow	YES	12	2-3	min. 40	2	4	cable/cap/wide strap/protective sleeve/shock absorber
Cobra 8t		8	polypropylene	28	17	109	100	knotless splice into cable hollow (quick splice) ≥ 50 cm	YES	12	2-3	min. 80	2	4	cable/cap/wide strap/protective sleeve/shock absorber
Cobra mini		-	polypropylene	8	12	6	5	knotless splice into cable hollow ≥ 30 cm	YES	12	2-3	min. 3	2	4	cable/cap/wide strap/protective sleeve/shock absorber
Cobra ultrastatic		-	dyneema	10	2	90	70	knotless splice into cable hollow ≥ 50 cm	YES	12	-	-	2	4	cable/cap/ultrastatic loop (120/160/200)

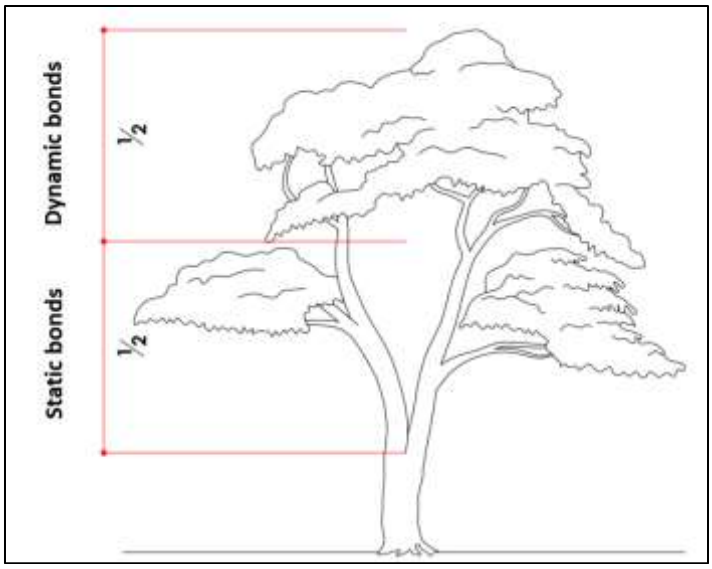
Type	Manufacturer	Carrying capacity [t]	Material	Cable diameter [mm]	Extensibility [%]	Cable carrying capacity at installation [kN]	Declared system carrying capacity [kN]	Splice type	Installation instructions available	Recommended service life on tree	Expected carrying capacity reduction/year [%]	System carrying capacity at end of service life [kN]	Recommended check interval (from ground) [years]	Recommended inspection interval (climbing) [years]	Components
Gefa Blue 2	GEFA Produkte Fabritz GmbH	2	polyamide	12	20	30	20	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 20	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Blue 4		4	polyamide	16	20	45	40	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 40	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Blue 7		7	polyamide	20	20	78	70	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 70	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Blue 10		10	polyamide	26	20	142	100	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 100	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year

Type	Manufacturer	Carrying capacity [t]	Material	Cable diameter [mm]	Extensibility [%]	Cable carrying capacity at installation [kN]	Declared system carrying capacity [kN]	Splice type	Installation instructions available	Recommended service life on tree	Expected carrying capacity reduction/year [%]	System carrying capacity at end of service life [kN]	Recommended check interval (from ground) [years]	Recommended inspection interval (climbing) [years]	Components
Gefa Green 2	GEFA Produkte Fabritz GmbH	2	polyester	12	5	29	20	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 20	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Green 4		4	polyester	16	5	56	40	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 40	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Green 7		7	polyester	20	5	84	70	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 70	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Green 10		10	polyester	26	5	142	100	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	2.5	min. 100	2^3-5^3	2^3-5^3	cable/protective sleeve or trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Dyneema 14		14	dyneema	16	2	-	140	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	-	min. 140	2^3-5^3	2^3-5^3	cable/trunk strap/splicing needle, coloured sleeve to mark installation year
Gefa Dyneema 20		20	dyneema	20	2	-	140	knotless splice into cable hollow as per instructions	YES in DE, EN[4]	8	-	min. 200	2^3-5^3	2^3-5^3	cable/trunk strap/splicing needle, coloured sleeve to mark installation year

Type	Manufacturer	Carrying capacity [t]	Material	Cable diameter [mm]	Extensibility [%]	Cable carrying capacity at installation [kN]	Declared system carrying capacity [kN]	Splice type	Installation instructions available	Recommended service life on tree	Expected carrying capacity reduction/year [%]	System carrying capacity at end of service life [kN]	Recommended check interval (from ground) [years]	Recommended inspection interval (climbing) [years]	Components
Tree Save Blue 2	TreeSave	2	polyamide	14	approx. 20	26	26	knotless splice into cable hollow	YES	8	approx. 2.5 (20% in 8 years)	min. 20	1	4[3]	trunk strap/splicing needle/installation identification
Tree Save Blue 4		4	polyamide	18	approx. 20	65	65	knotless splice into cable hollow	YES	8	approx. 2.5 (20% in 8 years)	min. 40	1	4[3]	trunk strap/splicing needle/installation identification
Tree Save Blue 8		8	polyamide	26	approx. 20	113	113	knotless splice into cable hollow	YES	8	approx. 2.5 (20% in 8 years)	min. 80	1	4[3]	trunk strap/splicing needle/installation identification
Tree Save Green 2		2	polyester	14	approx. 5	27	27	knotless splice into cable hollow	YES	8	approx. 2.5 (20% in 8 years)	min. 20	1	4[3]	trunk strap/splicing needle/installation identification
Tree Save Green 4		4	polyester	18	approx. 5	71	71	knotless splice into cable hollow	YES	8	approx. 2.5 (20% in 8 years)	min. 40	1	4[3]	trunk strap/splicing needle/installation identification
Tree Save Green 8		8	polyester	26	approx. 5	114	114	knotless splice into cable hollow	YES	8	approx. 2.5 (20% in 8 years)	min. 80	1	4[3]	trunk strap/splicing needle/installation identification
Tree Save Steel 8		8	-	12	0	90	-	-		-	-	-	-	-	cable/tightener/eye/clamp/washer
Tree Save Steel 12		12	-	16	0	140	-	-		-	-	-	-	-	cable/tightener/eye/clamp/washer

[3] Overloading indicator is visible as the case may be.

Annex 2 Illustrations



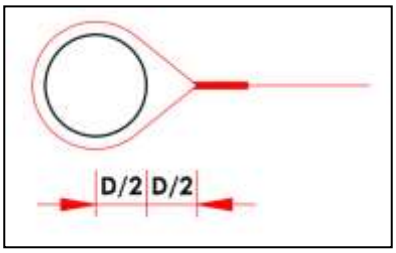


Fig. 1 Splice distance (2.2.7)

Fig. 2 Location of static (2.6.7) and dynamic bonds (2.6.24).

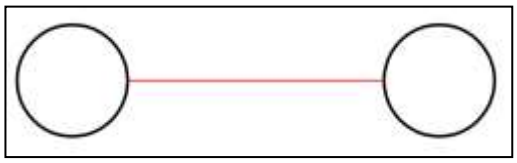


Fig. 3 Model example of direct bond (2.6.28)

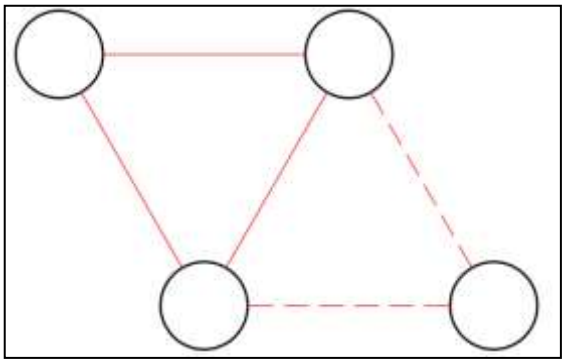


Fig. 4 Model example of triangle bond (2.6.29)

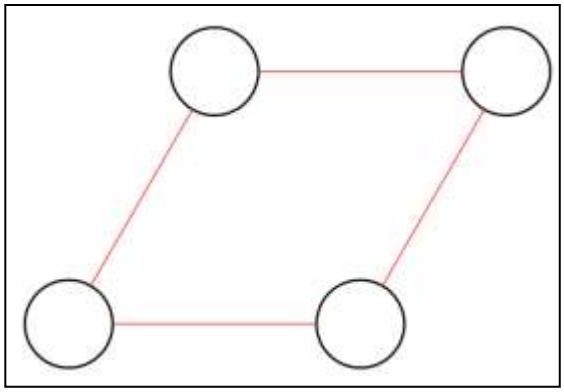


Fig. 5 Model example of circumference bond (2.6.30)

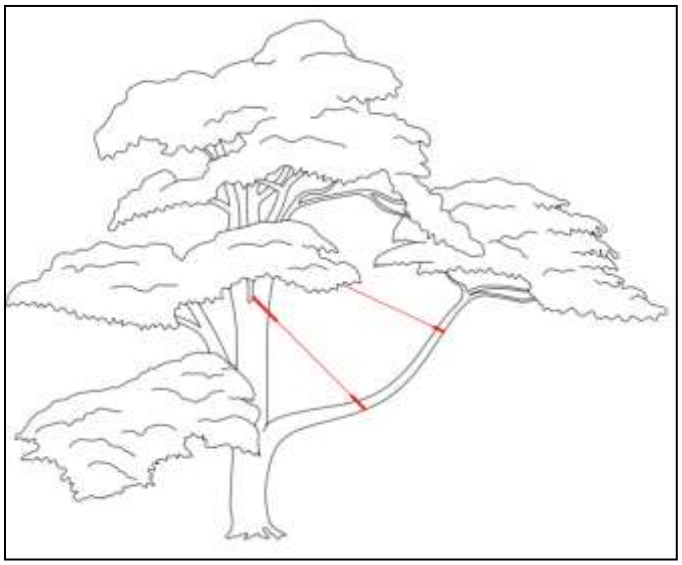


Fig. 6 Branch base stabilisation to prevent it falling on the ground

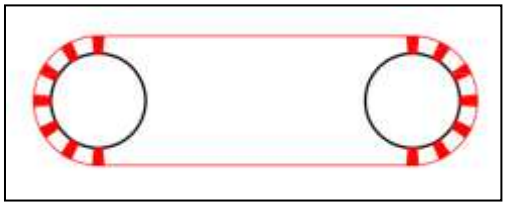


Fig. 7 Recommended method of installing a padded bond with an endless loop (2.3.11)

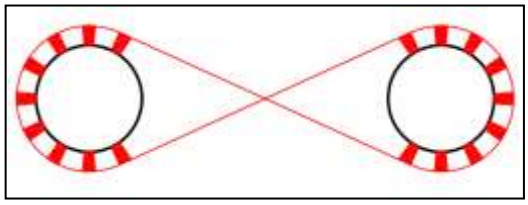


Fig. 8 Recommended method of installing a padded bond with a figure eight (2.3.11)

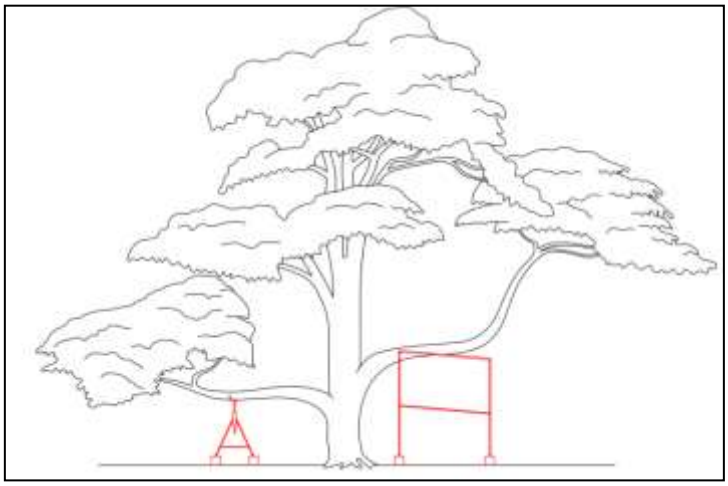


Fig. 9 Model example of brace shapes (2.5.7).

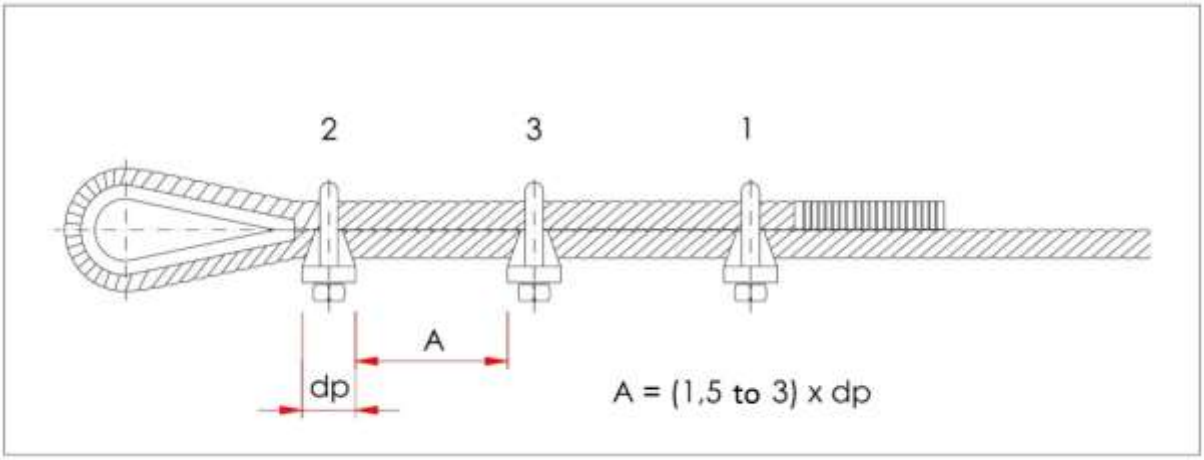


Fig. 10 Model example of clamp fastening when stressing one end of the cable (3.2.2)

Annex 3 List of Nature and Landscape Management Standards (Arborist Standards) developed

01	Inspection, assessment, planning
01 001	Tree assessment
01 002	Protection of woody plants during development activities
02	Work procedures
02 001	Planting of trees
02 002	Pruning of trees
02 003	Planting and pruning of shrubs and climbing plants
02 004	Crown security systems (cabling / bracing)
02 005	Tree felling
02 006	Protection of trees against lightning strike
02 007	Modification of woody plant site conditions
02 008	Woody plant stand establishment and management
02 009	Special tree treatment
02 010	Management of woody plants along public transport infrastructures
02 011	Care of woody plants along utility lines

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