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# Europacable
# Technical newsletter
# Fibre to the Home
# Aerial cables in FTTH

**June 2023**

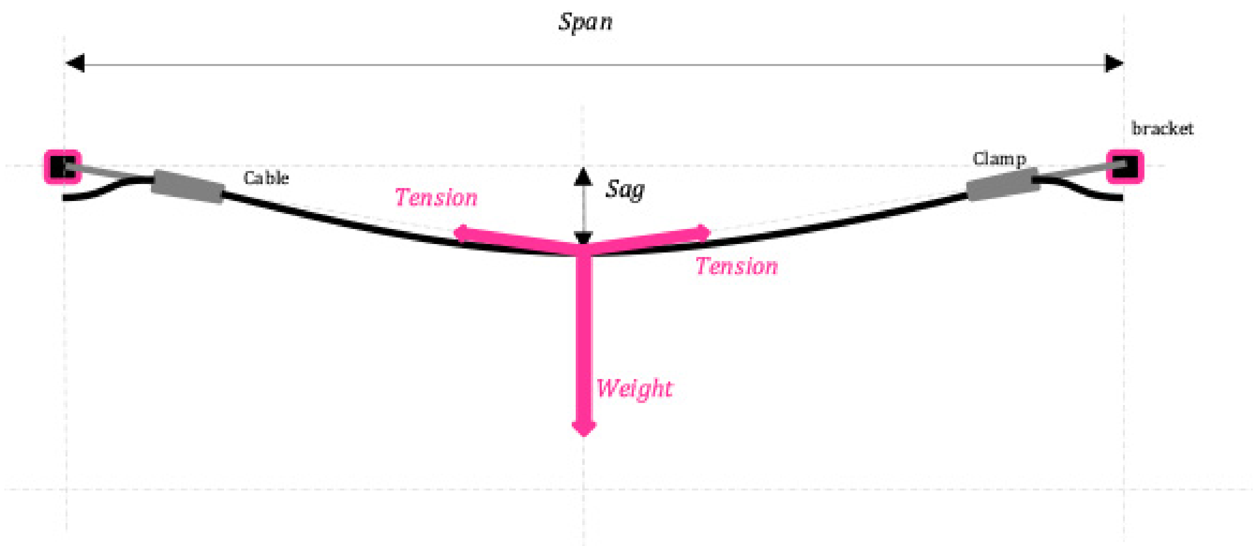
This document is part of a suite of Newsletters published by EUROPACABLE:
We encourage recipients to read all of them and to pay particular attention
to the Newsletter “Optical Reliability of optical infrastructure”
and “Understanding an optical fibre datasheet”

# 1. Introduction

The installation of optical aerial cables is increasingly used in FTTH roll out. The main reasons are to achieve a lower initial CAPEX and a faster installation practice than buried or duct installations, especially when using existing overhead infrastructure.
But overhead infrastructures are exposed to climatic constraints during their whole life and products and installation must comply with specific requirements, addressed in this paper.
(Note: in this newsletter we do not cover aerial cable installed in the vicinity of power overhead lines)

# 2. Installation of Aerial Cable

The installation of aerial cables (or lines) has been in place for decades, using wooden poles at the beginning with concrete, composite or metallic poles now being used.
The first important parameter when considering an aerial installation is the distance between the poles called the span L[m].
The second parameter is the sag f[m] or f/L x100 [%] (see figure).
Both parameters are often used to calculate the installation parameter.




In most cases a good approximation of the relationship between the span, the sag and the induced mechanical tension [N] is given by the catenary formula when there is no wind or ice effect:

$$\text{Tension} = \frac{\text{Weight} \times \text{Span}^2}{8 \times \text{Sag}}$$

Where,

- Weight (in Kg/m): Weight of one meter of cable
- Tension (in daN): Calculated tension load applied to the cable and clamp
- Span (in m): Distance between two poles
- Sag (in m): Vertical distance at the center of the span, usually equal to 1% or 1,3% of the span

As a numerical example, If we consider a case where:

- W= 0.102 kg/m
- L= 50m
- f=0.65m (equivalent to an installation factor 1.3%)

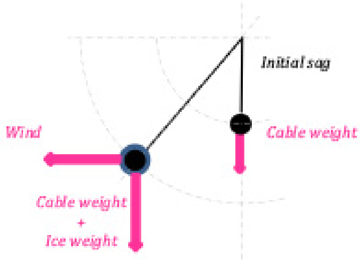
Applied tension is equal to 48daN (480N).

Please note the quadratic effect of the span on the tension and the inverse effect of the sag: so doubling the span will increase the tension by a factor 4 and a decrease of the sag by a factor 2 will double the tension in the cable! This means that if the tension on the pole has to be reduced, reducing the span or increasing the sag can be smart solutions. This leads also to select cable as light as possible.

## Taking into account additional loads caused by bad weather:

The effects of external influences must be considered; mainly the effect of wind, temperature, the possible ice loading… and the combination of all these extraloads.

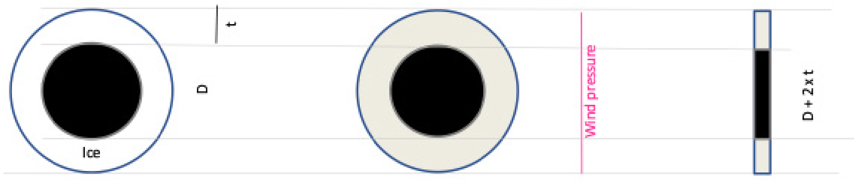



Bad weather conditions induce additional load on overhead infrastructures. The ice load increases the cable weight as well as the total surface subject to the wind.

$$apparent\ weight = \sqrt{(ice\ weight + cable\ weight)^2 + (applied\ wind\ force)^2}$$

The above formula takes into consideration weather conditions and their impact. Thus, wind and ice loads are integrated in the apparent cable weight calculation:




The energy of wind will generate a dynamic pressure on the cable proportional to the square of the wind speed and to the diameter of the cable (inflated by the possible ice load). In other words, the extraload will be an horizontal force according to the below formula:

$$F_W \propto V_W^2 \cdot D$$

Where,
$F_w$: Load due to the wind (N/m)
$V_w$: the wind speed (m/s)
D: the cable diameter (+ice effect – it is a common practice to approximate the ice loading by the additional linear weight or by the ice thickness e: if the ice thickess is e, the total width to consider for the wind effect is D+2 x e)

Just to give a numerical example, a wind with a speed of 94 km/h will generate a dynamic pressure of approx. 480 Pa; in the case of our 10mm diameter cable we get an horizontal force of 4.8 N/m. Nearly 5 times the linear weight!
Temperature effect
The effect of temperature must be taken into account via the coefficient of thermal expansion of the cable CT° [%/°C] and the mechanical modulus of the cable (ExS)[N]

E: Young modulus of the cable [N/mm²]
S: the surface of the cable [mm²]

Temperature variation has an impact on plastic's contraction or dilatation. With cold temperature, thermal contraction occurs and generates an increase of the tension of the cable on the pole. At the opposite, with warm temperature, plastic dilation generates a load decrease on the pole.

## Conclusion and Europacable recomandation:

**The existing poles are very often supporting a lot of cables; it is recommended to install as small and light optical aerial cable as possible in order not to overload the poles.**
**Small diameter cables will further induce less additional strain on the poles (wind, ice...)**

### Local load conditions

Defining the local weather conditions, where cables are rolled out, it is very important to anticipate constraints. Different weather condition models can be used and they are often specified by the owner of the network, by legal rules or by the state of the art technology.

As an example, in France, extracted from national law, weather conditions to be taken into account are as follows:

| |
|---|
| C0: 15°C |
| A1: 15°C / wind 360Pa (83,23km/h) |
| A2: 15°C / wind 427,5Pa |
| C1: 15°C / wind 480 Pa (94,068 km/h) |
| C2: 15°C / wind 640 Pa (111,024km) |
| A3: 15 ° / wind 720 Pa (115 km/h) |
| B1: -10°C / wind 135 Pa (51,12 km/h) |
| B2: -20°C / wind135 Pa (52,12km/h) |
| G1: -5°C / wind 480 Pa (94 km/h) / ice load 1 kg/m |

American state of the art recommendions are to use for examples such as NESC conditions which are described by the following weather conditions:

| | | Temperature | Ice thickness | Wind pressure |
|---|---|---|---|---|
| NESC RULE 250B | HEAVY | -18°C | 12.7mm | 192Pa |
| | MEDIUM | -10°C | 6.35mm | 192Pa |
| | LIGHT | -1°C | 0mm | 431Pa |

Of course, all these environmental conditions are country dependent (even regionally dependent) and the cable design and performances depend on the choice of the weather condition parameters.

In the following table you will find the full modelisation for an aerial optical fibre cable to be installed with a span between 30 and 70m. Different set of extra loads conditions are evaluated.

For a span of 70m and an initial sag of 0.91m when installed at 10°C, the cable tension is 81.7 daN; under the A2 conditions, the sag becomes 1.92m and the tension 215.5 daN. For more severe conditions (A3 or G1) the span must be restricted to 50m in order to respect the max cable allowable tension of 235daN (given for 0.3% fibre elongation to ensure more than 25 years lifetime – see next chapter)

| Cable data | |
|---|---|
| Cable diameter D | 12.5 mm |
| Cable mass | 112 kg/km |
| Cable Section | 125 mm² |
| Young modulus | 6880 MPa |
| Coefficient of thermal expan | 1.3 *10-6/°C |
| MAT | 235 daN |

| Extra loads conditions |
|---|
| C0 : 15°C |
| A1 : 15°C / Wind pressure 360Pa |
| A1 : 15°C / Wind pressure 427,5Pa |
| A2: 15°C / Wind pressure 480 Pa |
| A3: 15 °C / Wind pressure 720 Pa |
| B1 : -10°C / Wind pressure 135 Pa |
| B2 : -20°C / Wind pressure 135 Pa |
| G1 : -5° / Ice 1kg/m |

| Span (m) | | Temperatue effect on initial installation | | | | | | Extra loads conditions | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | °C | -10 | 0 | 10 | 20 | 30 | 40 | C0 | A1 360 Pa | A1 427,5 Pa | A2 480 Pa | A3 720 Pa | G1 |
| 30 | Sag(m) | 0.38 | 0.38 | 0.39 | 0.39 | 0.40 | 0.40 | 0.39 | 0.62 | 0.65 | 0.68 | 0.77 | 0.79 |
| | Tmax(daN) | 35.80 | 35.50 | 35.10 | 34.70 | 34.40 | 34.00 | 34.90 | 93.40 | 104.30 | 112.50 | 147 | 159 |
| 40 | Sag(m) | 0.51 | 0.51 | 0.52 | 0.52 | 0.53 | 0.53 | 0.52 | 0.87 | 0.93 | 0.96 | 1.1 | 1.14 |
| | Tmax(daN) | 47.60 | 47.20 | 46.80 | 46.30 | 45.90 | 45.50 | 46.50 | 117.40 | 130.60 | 140.50 | 182 | 197 |
| 50 | Sag(m) | 0.64 | 0.64 | 0.65 | 0.65 | 0.66 | 0.66 | 0.65 | 1.15 | 1.22 | 1.27 | 1.46 | 1.51 |
| | Tmax(daN) | 59.40 | 58.90 | 58.40 | 57.90 | 57.40 | 57.00 | 58.20 | 139.90 | 155.20 | 166.70 | 215 | 231 |
| 60 | Sag(m) | 0.76 | 0.77 | 0.78 | 0.78 | 0.79 | 0.79 | 0.78 | 1.43 | 1.52 | 1.59 | | |
| | Tmax(daN) | 71.20 | 70.60 | 70.10 | 69.50 | 69.00 | 68.50 | 69.80 | 161.40 | 178.70 | 191.60 | | |
| 70 | Sag(m) | 0.89 | 0.90 | 0.91 | 0.91 | 0.92 | 0.93 | 0.91 | 1.73 | 1.84 | 1.92 | | |
| | Tmax(daN) | 82.90 | 82.30 | 81.70 | 81.10 | 80.60 | 80.00 | 81.40 | 182.10 | 201.20 | 215.50 | | |

For a standard sag of 50 m and extra load going from C0 to G1 we can see that the cable tension is going from 58,2 daN to 231 daN (nearly **4 times the initial tension** with no wind and no ice).

# 3. Impact on the cable design

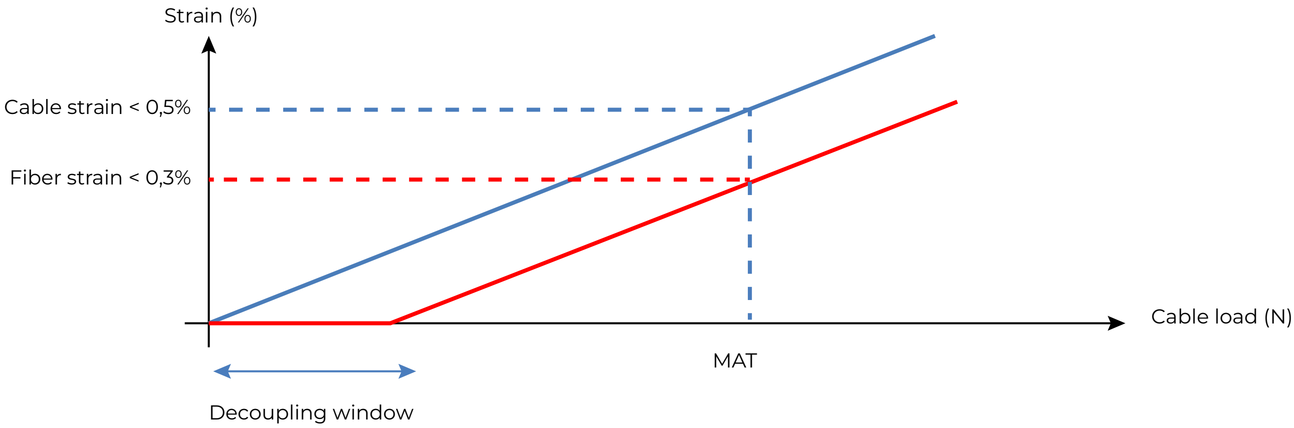
It is obvious that an aerial cable will be submitted to variable and sometimes very high mechanical tension during its whole life. If we expect a lifetime of more than 40 years, it's worth to pay attention to optical and mechanical fibre reliability (See also "Expected Life time of Passive optical infrastructures" and the Newsletter "Optical Reliability and Understanding an optical fibre datasheet"). Even in the worst case, conditions are not always present we recommend a conservative approach and to limit the span to respect the maximum allowable tension of the cable MAT.

RECOMMENDED BY EUROPACABLE

**In FTTH deployment EUROPACABLE strongly recommends designers to respect a maximum 0.3% fibre elongation and 0,5% cable elongation at the MAT to ensure FttH overhead insfrastructure reliability.**

Cables offering a mechanical decoupling between fibres and cables are very good candidates for aerial deployment: this gives the opportunity to reach longer span with limited reinforcement without increasing the load on existing poles.

The theoretical chart below shows the decoupling window reaching 0.2% equivalent usually 10 to 20% of the maximum allowable tension; in combination with the acceptable 0.3% fibre strain, we can indeed defined the MAT, maximum allowable tension.




Aerial cables could be based on micromodule or drop design, and on loose tube elements. In any case, further to the fibre excess length, when available, then the MAT is defined by the reinforcement elements (Fibre Reinforced Polymer, aramid yarns, ...). All these elements will have an impact on the linear weight and the diameter of the cable (see examples below). For aerial cables, whatever the structure is, the aim is to reduced cable size and weight.

## Optical cables for FTTH overhead network examples:

Stranded loose tube

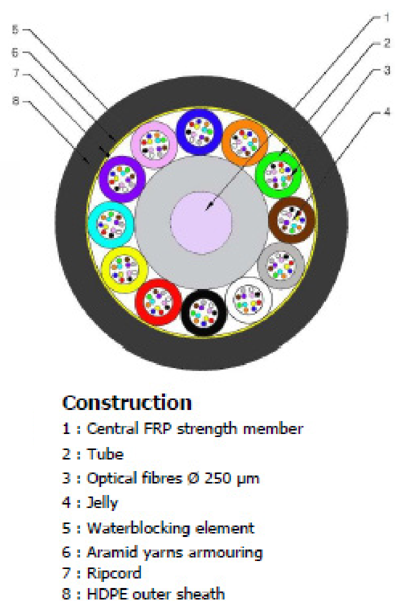
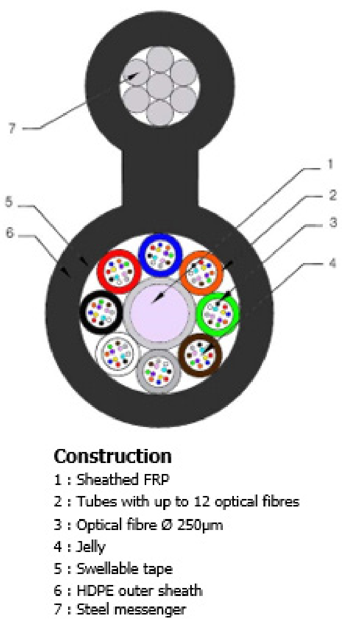
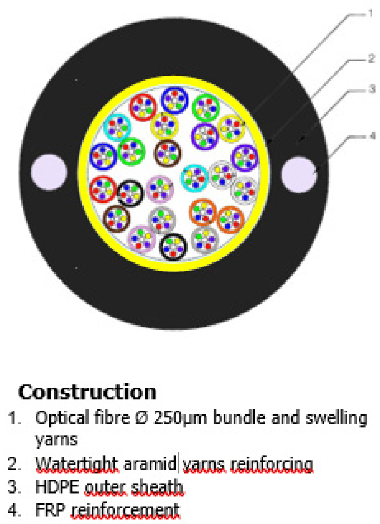


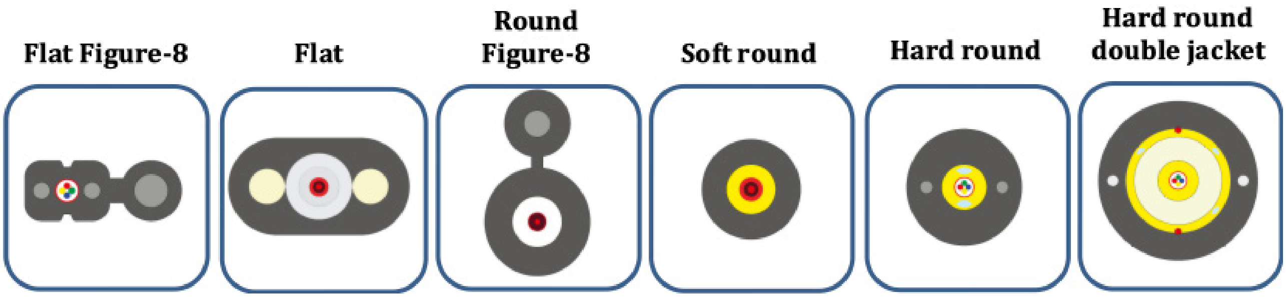

Figure 8




Micromodule



Optical drop cables for access network  examples

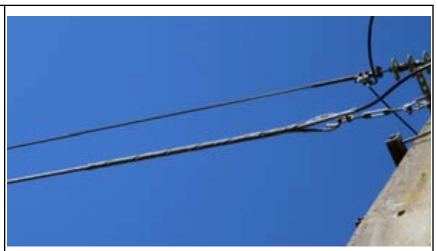
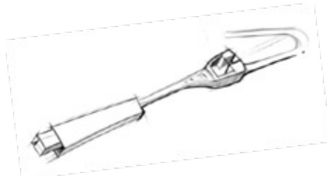



Double jackets are often used to allow direct connection to end user, without a splice or a fibre connection, from an outdoor environment to the indoor safety compliant requirements. Removing the outside jacket gives access to an indoor cable that has to be compliant with local fire regulations.

# 4. Fittings for Aerial cable

The table below presents the different existing principles to clamp an overhead cable on a pole. The common physical phenomena for all theses technologies is that the more the cable is pulled, the more the cable is tightened into the clamp.

| | | |
|---|---|---|
| **Jaws clamps**<br> | The principle consists of 2 symmetrical jaws around the cable inside the clamp body. Jaws are shaped to have a perfect adaptation to the cable and provide a quick  installation without the use of tools and an easy cable sag adjustement.<br><br>No contact between the cable and the clamp body provides a real insulation in case of plastic jaws and metallic body.<br><br>Vibrations are absorbed  and create off-sets with interchangeable bail from the support and support very high loads.<br><br>Compatibility: round cables with FRP rods, loose tube stranded round cables or figure-8 cables with steel or dielectric messengers (spans up to 180m). |  |
| **Wedge clamps**<br> | Solutions based on a single wedge and body design ensuring an enhanced adap-tation to the cable as well as an efficient cable grip.<br><br>Compatibility: round, flat fibre optic and communication copper cables. |  |

| | | |
|---|---|---|
| **(double) HELICAL or spiral Dead-ends**<br> | Metallic rods wrapped around the cable providing a wide contact surface with the cable, this technology is suitable for maintaining round cables rolled out on long spans (up to 250m) and in harsh installation conditions and supporting high loads. Can be completed with armoured rods.<br><br>Discreet, they require additional accessories to create offsets from support to comply with the cable bending performances. |  |
| **Mandrel clamps**<br> | This technology consists in to self-tightening of the cable around the mandrel, based on a capstan effect. This preserves the cables from piston effects for all types of spans. It enables quick, easy and toolless installation, as well as simple sag adjustement.<br><br>Especially recommended for small diameter cables built without FRP rods and/or a non-dense outer sheath. |  |
| **Pinch clamps**<br> | Commonly used with flat cables, the cable anchoring is carried out thanks to roughnesses created on a dedicated shim. Cable is pinched between the body and the shim. A wedged bail enables the tightening and the hooking to the pole. | <br> |

In addition, suspension devices complete the set of aerial accessories related to cables. Four main technologies are presented below to suspend cables between two anchors.

| | | |
|---|---|---|
| **J HOOK SUSPENSION CLAMPS** | This technology enables the deployment of a cable on several consecutive poles without using intermediate pulleys.<br><br>Installation on cross-arms (fixed suspensions) or poles (fixed and mobile suspension applications). |  |
| **SHELL BODY SUSPENSIONS** | Compatible with round or flat cables, suspension clamps offering a hinged body shell design can be installed on all type of poles. |  |
| **SUSPENSION GROOVED PADS** | This technology is used for figure-8 cables with steel or dielectric messenger. Designed with two grooves to adapt to different messenger diameters. Available for fixed or mobile suspension applications. |  |

| | | |
|---|---|---|
| **HELICOIDAL TANGENT SUSPENSION** | Device consisting in a spiral mettalic rod right and left wrapped on a round cable. Fixation on pole are made at the wrap-ping inversion through mobile or fixed devices. |  |

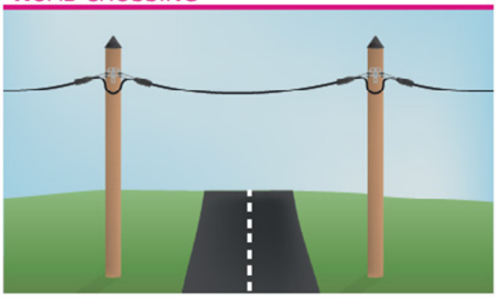
## Making the right equipment choice: THE RADAR METHOD

To help you select the right solution between anchoring and suspension devices, it is suggested to use the following RADAR method. This requires consideration of 5 essential criteria.

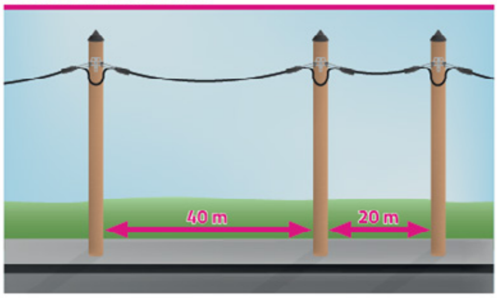
### Europacable recommendation: radar decision table

| | Anchoring | Suspension |
|---|---|---|
| ROAD CROSSING | Yes | No |
| ASYMETRIC SPAN | Yes | No |
| DEVIATION | Angle >25° | Angle <25° |
| ALIGNMENT SEGMENTATION | Every 5 poles | Up to 4 poles |
| RUGGED TERRAIN | Yes | No |

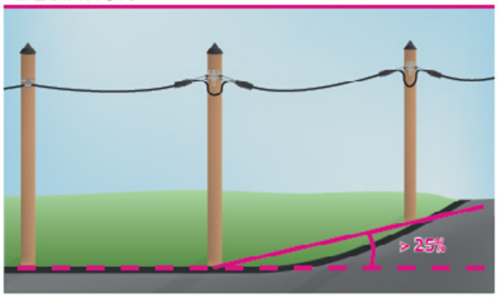
ROAD CROSSING



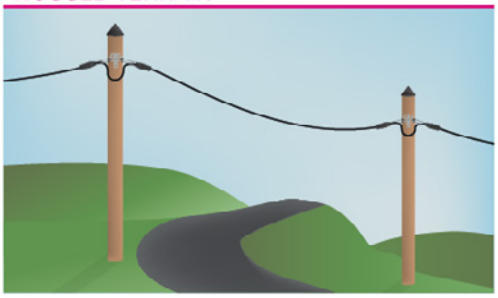
ASYMETRIC SPAN



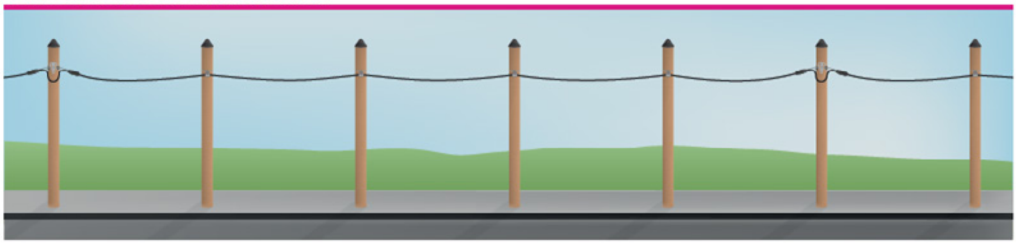

DEVIATION




RUGGED TERRAIN



ALIGNMENT SEGMENTATION



As a general rule, anchoring clamps or helical dead-ends can be used on all type of poles for securing a cable at the required horizontal tensioning and height. Suspension devices however have to be installed on intermediate poles: they maintain a cable at the correct height (vertical resistance).

The choice between anchoring and suspension is determined thus by the network configuration. The overhead line layout, the typology, the span range type, as well as the topography and the alignment segmentation are 5 of the essential criterias to consider for making the right equipement choice for each roll-out project.

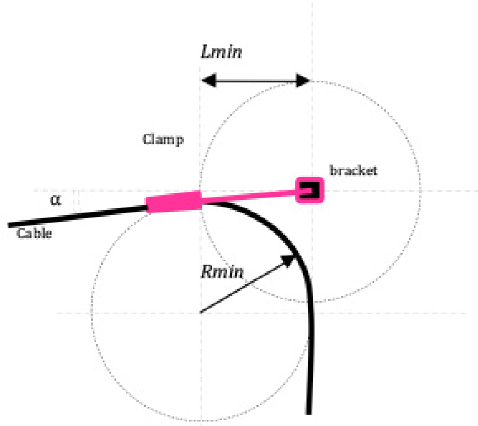
## Cable in curve or how to determine the appropriate bail length for the clamp

A clamp's bail length is directly related to the cable bending performances. The lower the cable bending performance, the shorter the bail length may be.

Two configurations have to be distinguished:

- **Simple anchoring**

$$L_{min} = \frac{R_{min}}{\cos(\propto)}$$




$\propto$ is related to the sag, and in case of sag of 1% to 3%, $\cos(\propto) \sim 1$

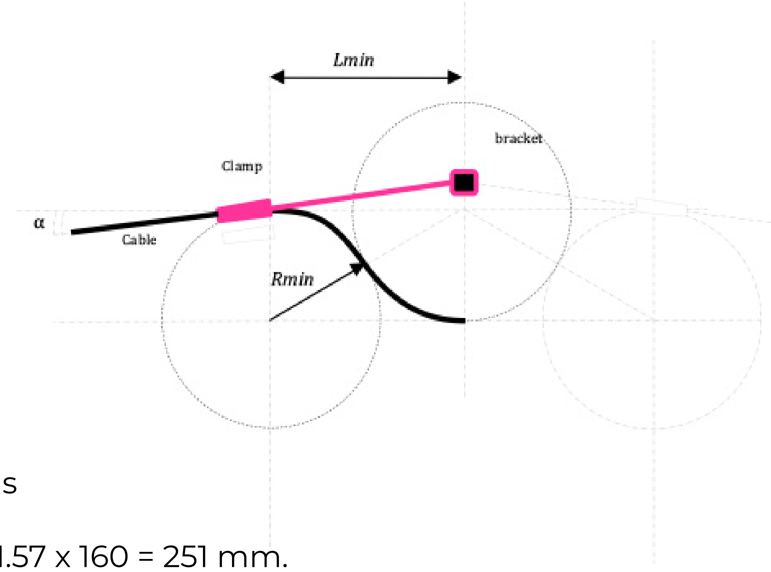
Example:

If cable diameter is 5mm and the minimum bending radius is 100 mm (20x Ø), thus, in this case, it results that the minimum bail length is 100mm.

- **Double anchoring**

Assuming that the angle, $\cos(\propto)\ 1$ due to the ratio cable sag over cable span is minor and , the bail length is directly related to the minimum bending radius of the cable and it can be determined by using the following formula:

$$L_{min} = \frac{\frac{\pi}{2} \times R_{min}}{\cos(\propto)} \quad 1.57 \times R_{min}$$



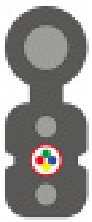
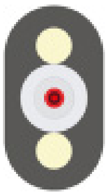
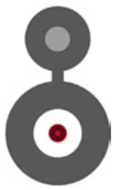
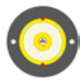
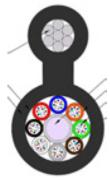

Example:

If the cable diameter is 8mm and the minimum bending radius is 160mm (20x Ø), it results in the minimum bail length being: 1.57 x 160 = 251 mm.

## Cable – clamp compatibility

Obviously, the suitable clamp technology depends on the cable design.

Due to various cable designs and anchoring technologies, a preliminary table guides the choice of cable-anchor couples

| |  |  |  |  |  |  |  |  |  |
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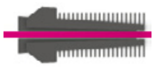
|  | O | O | O | X | O | O | O | O | O |
|  | O | X | O | O | O | O | X | O | X |
|  | O | X | O | X | O | O | O | O | X |
|  | X | X | X | O | X | X | X | X | X |
|  | O | O | X | X | X | X | X | X | X |

## Europacable advise:

**considering the sustainability and reliability of the network, it is essential that the pole hardware and anchors be adapted and qualified for the network on which they will be deployed. The mechanical connection between the anchor and the cable therefore constitutes an important issue for overhead network. Compatibility of the anchors and cables is checked by carrying out the following qualification tests:**

- **Tensile tests at the short-term tensile load of the cable (Maximum Allowable Tension) according to standard EN 60794-1-2 modified E1 method, involving a couple of anchoring devices on a cable length greater than 50 meters. <u>There should be no slippage of the cable inside the anchoring clamps, no deterioration of the cable, nor deterioration of the signal (attenuation less than 0.1dB at 1550 nmand remains at initial value after test). The fibre strain shall not exceed 0.3%</u>.**

- **Vibration test for anchor clamps according to standard EN 60794-1-2 Method E19, and by applying 10 undulations for cables of diameter less than or equal to 6mm (drops), 3 undulations for cables with a diameter greater than 6 mm (distribution and transport cables) and an optical measurement of losses for 300 hours. The optical losses must then be less than 0.1 dB at 1550 nm throughout the test <u>and remains at initial value after test</u>.**

# Conclusion:

In the context of aerial FTTH deployments, cables and anchors constitute a set of inseparable technical solutions which must also contribute to the durability of fiber optic networks.

Also, it is important to anticipate the rollout by choosing the most appropriate equipments taking into account topological conditions (sag, span, ground slope, road crossing, etc...) and climatic conditions (temperature, presence of ice, wind max. velocity,...).

These preliminary studies are necessarily supplemented by tests which allow to check the compatibility of the cables and anchorages and thus to guarantee the robustness of the solutions chosen.

It is recommended to follow the advice highlighted by Europacable in this document and identified by the following logo:

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**About Europacable**

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