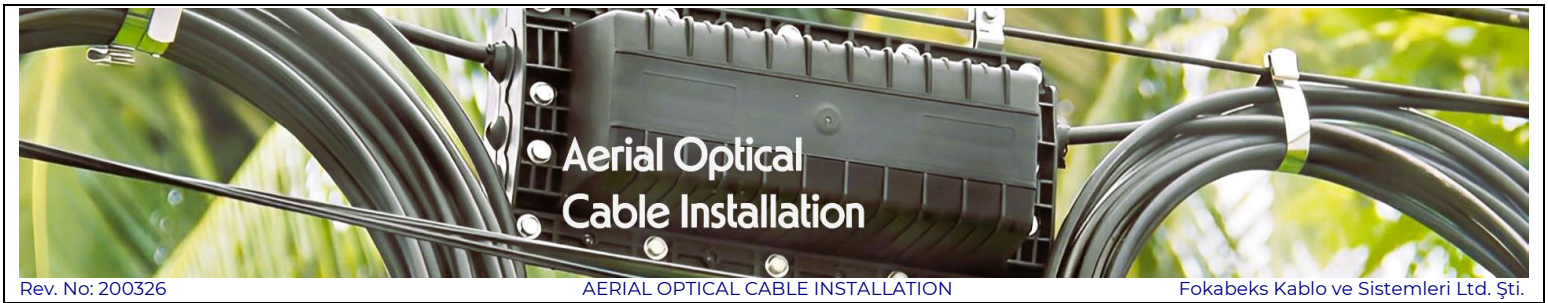

FOCABEX

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INSTALLATION OF AERIAL OPTICAL FIBER CABLES

1. FIGURE EIGHT" FIBRE OPTIC CABLES
2. LASHED TYPE FIBRE OPTIC CABLES
3. ADSS (All Dielectric Self Supported fibre optic cables)
4. OPGW (Optical Ground Wire)

The installation methods for fibre optic cables are largely the same as those with conventional copper cables.

It is, however, important to observe the limiting values for the cable, given by the cable manufacturer, such as:

* minimum bending radius
* maximum pulling force
* minimum installation temperature
* crush strength of the cable

These may be considerably different from those of the copper cable.

Loads that exceed the ratings may increase attenuation in the fibres up to the point of causing fibre breaks. The fibres may break immediately or after some time. The damage may not be visible on the outside of the cable. The cable may seem intact, while in fact the fibre is stretched, or there are microfissures which may cause an early break.

Aerial cables are typically filled with jelly. These cables are normally provided with a metal laminate,(aluminum foil or corrugated steel tape), to protect them against moisture. (The cable can also be non-metallic). The jelly prevents the passage of water in longitudinal direction while it at the same time protects the fibres.

In general where end-pull or distributed pull methods are used the various methods as in underground duct installations to protect the cable from excessive strain during installation may also be employed for aerial cable. It is also important that proper guiding equipment is provided at positions where sharp changes of direction occur.

It is important when installing aerial optical fibre cable lengths to make proper arrangement for an adequate extra length of cable at a pole position for testing and jointing. This length at each end of cable must be sufficient to enable construction of joints at a convenient work position and it may be necessary to allow extra length for ground level operations.

Aerial installation is perhaps the most economical alternative when existing lines of poles can be used.

1. "FIGURE 8" FIBRE OPTIC AERIAL CABLES.

*** Easy and fast to install**
*** Span lengths up to 100 m and more**
*** Allows high fibre counts**
*** Installation in telecommunication pole lines**

These cables are self supporting cables with an integrated messenger wire in the cable sheath.

The messenger gives the cable a sufficient tensile strength and resistance to strain.

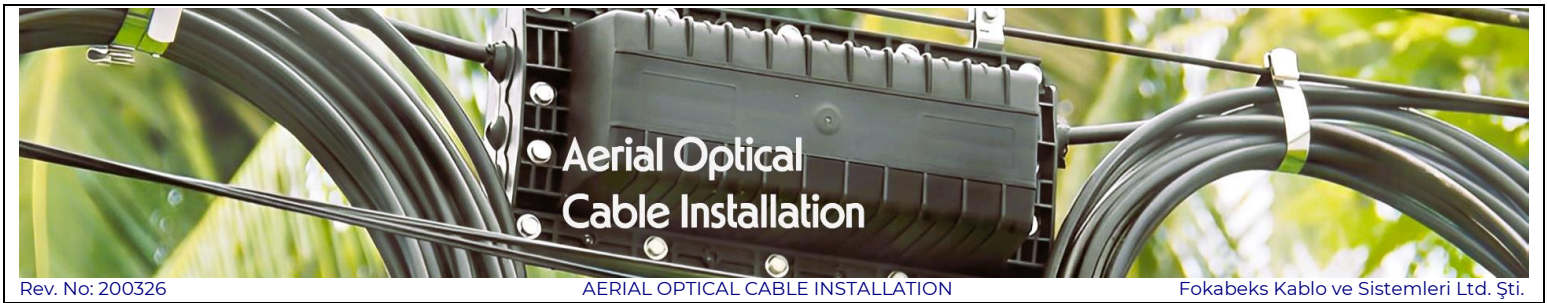
The messenger is normally a galvanized 7-wire messenger, 7x 0.7 mm up to 7x2.12 mm or more, depending on the dimension of the cable. In non-metallic cables the steel messenger is replaced by a single fibre reinforced plastic rod (FRP).

The cable constructions have been designed to provide for a stable attenuation of the fibres in a wide temperature range (+70°C...-45°C). The figure 8 cable is suspended onto poles, made of wood, metal or concrete.

The pole span is typically 50....100m, but also longer spans may be built. The cable sag is adjusted according to engineering specifications and is secured by the suspension clamps on poles and by dead-end clamps at the ends of the aerial line.

The same mounting accessories may be used with fibre optic cables as with traditional copper cables. However the splice closures are usually mounted on the poles.

The appropriate accessories are mounted on the poles before the cable is laid. The cable is spread out under the poles directly from the truck, if possible. A crawler tractor with a cable trolley can be used in difficult terrain, or the cable can be spread out by manpower.



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At the end of the line, the cable is lifted up on the pole, positioned and tightened properly, and fastened to the hangers. Drawing rolls are used on the poles when the cable is drawn, to avoid its rubbing against the pole or the hanger.

The sag of the cable is dependent on the temperature and the pole distances.

To avoid, as well as possible, defects caused in the sheath by e.g. wind, rime or ice load, the following advises should be followed:

* The best hanger for an aerial figure 8 cable is one that allows both longitudinal and transverse movement of the cable.

* It is also recommended to separate the messenger from the cable by cutting the neck over a length of 50 ...60 cm at the hanger, to prevent damages by oscillation or vibration.

* It is also recommended to twist the cable axially by 5...10 turns on every second pole, to prevent swinging of the cable.

2. LASHED TYPE FIBRE OPTIC CABLES.

*** The same cable might be used both for aerial- and underground installation.**
*** Span lengths up to 100 m and more**
*** Allows high fibre counts**
*** Installation in telecommunication pole lines**

The cable construction is similar to Duct- or Direct buried cables. The cable is lashed with aluminum- or steel-wire to a separate,pre-installed, messenger wire. Installed on wooden, steel or concrete poles. The pole span is typically 50....100m.

The cable can be lashed by hand or with special lashing equipment. If the line contains both aerial and direct buried section the same cable could perhaps be used for both applications.

Where lashing to pre-tensioned messenger wire is employed the optical fibre cable must be constructed to withstand lashing. The lashing-wire tension must be controlled.

3. ADSS (All Dielectric Self Supporting fibre optic cable)

*** Non-metallic cable**
*** Can be installed in power-lines**
*** Allows high fibre counts**
*** Allows high span lengths**
*** Conducting when wet or polluted!**

The ADSS cable can be installed in existing power lines and it is a complementary to Optical Ground Wires.

Can be installed with standard types of accessories, e.g. spirals, dampers, but needs separate support constructions.

Standard conductor installation equipment can be used. The installation is quite simple due to flexibility and low weight of the cable. Installation speed app. 2 to 4 km/day/team.

During installation of the ADSS cable it can be considered to be non-conducting and sometimes can be installed without disconnecting the line (if regulations allow).

During service these cables become semi-conducting because of pollution on the surface and the hydrophilic nature of the jacket material.

They may temporarily become significantly conducting because of humidity or moisture and thus have to be considered as conducting cable affected by electric fields. This fact should be considered during maintenance.

Splicing is normally carried out at ground level and the cable dressed up the support and housed at a height beyond the reach of the public. Alternatively the joint may be housed in an underground chamber.

In the event of cable damage the complete span must be replaced as mid-span joints are not practical or recommended.

It is however very important to calculate the electrical field and induced voltage and analyze the clashing behavior to find the optimum fixation position of the cable in order to reduce the exposure to tracking and/or corona effects.

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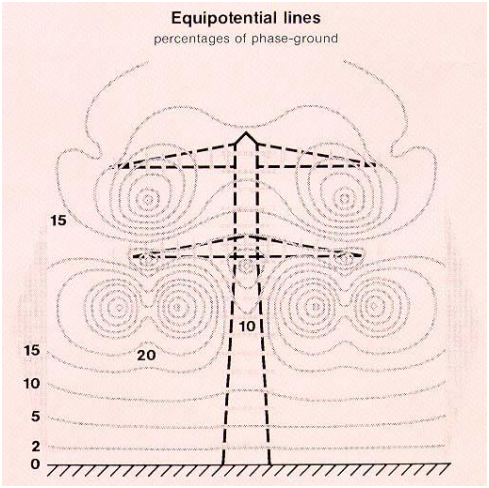

A particular phenomena of an installed ADSS cable is the "dry banding effect". This is due to the uneven drying of a dampened polluted cable where the electric stress is presented over a short distance of the dried part of the cable, causing local arcing and heating which may erode the cable sheath and strength member, leading to mechanical failure.

The ADSS cables effectively separate the telecommunication and power supply systems, a particular attractive feature when considering maintenance and repair to either system. With suitable planning, the cables can be installed without interference to the power supply.

4. OPGW (Optical Ground Wire).

*** Two function aerial conductor (optical fibres are embedded into a conductor)**
*** Can be installed in the same way as normal ground wire**
*** Allows high fibre counts**
*** Allows high span and delivery lengths**
*** Easy and fast maintenance**

OPGW conductors are normally installed at the top of the overhead line support structure and thus subjected to aeolian vibration, wind induced galloping, ice and wind loads, lightning strikes and maybe also ground fault currents.

Therefore is it essential that the constructor use fittings, accessories and installation methods approved by the OPGW manufacturer.

OPGW is designed to operate continuously at ambient temperatures which can vary from -50°C to +80°C.

All the cable components have to withstand temporary high temperatures caused by ground fault currents and wiring, especially the outer layer, which has to withstand lightning strike induced heath.

The duration of the lightning strike (including all its components) is in most cases less than 0.5 ms. The thermetic effect is thus only in a small area at the conductor surface. In a high energy strike, aluminum or aluminum alloy wire is more liable to immediate breakage than aluminum clad steel wire.

As most of the strikes happen at the poles, the preformed fittings are a good protection for OPGW. Damage resulting from lightning strikes is not considered to be a high risk.

OPGW can be installed the same way as normal ground wire (unless the manufacturer has stated otherwise). Scratching of the aluminum coated strands should be avoided in order to prevent corrosion.

The splicing of the fibres can be done either on the ground or at the top of the support structure. Some extra length is needed if the splicing is done at ground level but the splicing is easier to carry out.

The lengths installed depends on the line route, maximum length the manufacturer can deliver and the maximum pulling force allowed. In most cases however 3...5 km length is optimum. The longer the length the less splices and joint closures are needed.

If OPGW is damaged (by lightning in very rare cases or by vandalism) the whole span should be replaced.

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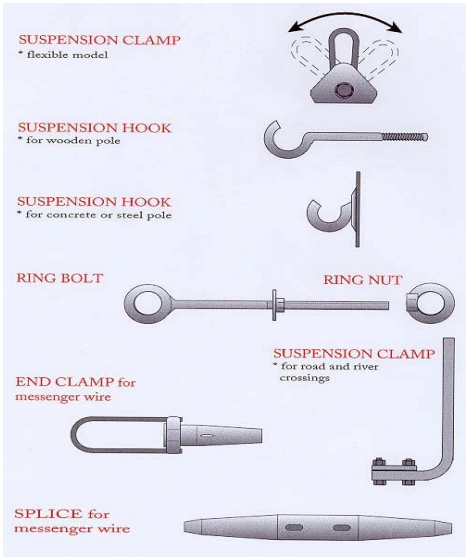
It may be good practice to monitor the attenuation of spare fibres from time to time (say, every 2-3 years). This will enable early detection of impending failure of a link before disruption to the service occurs.

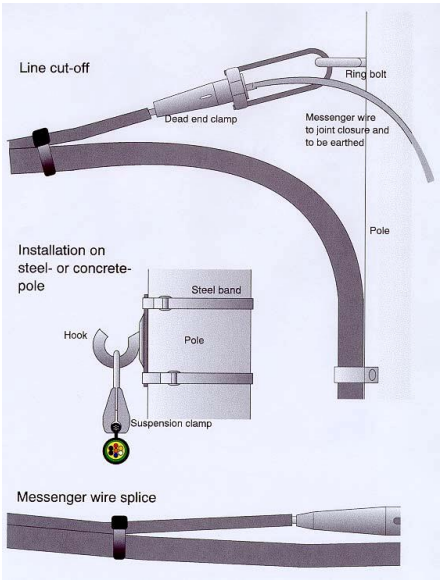
OPGW is at its best when installed as new line or when old ground wire has to be changed. OPGW is also considered to be the most proven reliability fibre optic cable for Power Utility usage. When doing the cost comparison it has to be remembered that the existing ground wires and even support structures have to be changed anyway sooner or later.

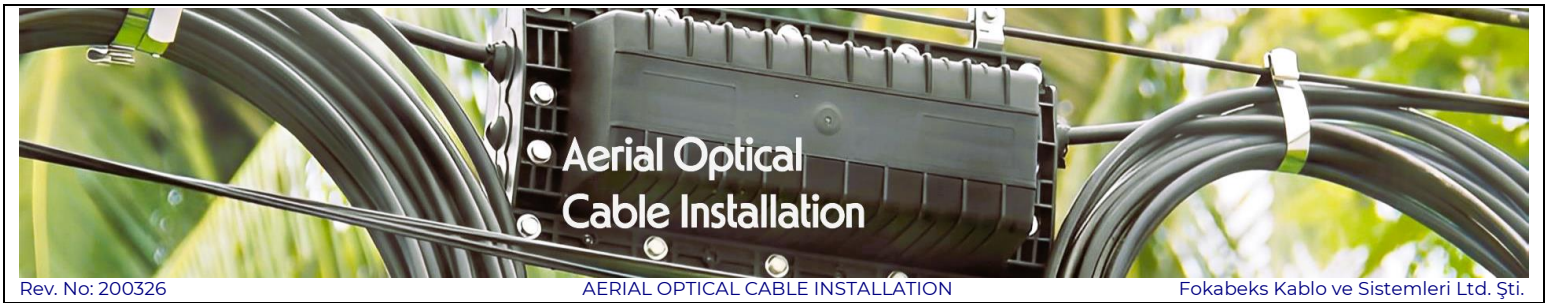
Appendix

Typical installation accessories for "figure 8" fibre optic aerial cable



Installation examples of "figure 8" fibre optic aerial cable





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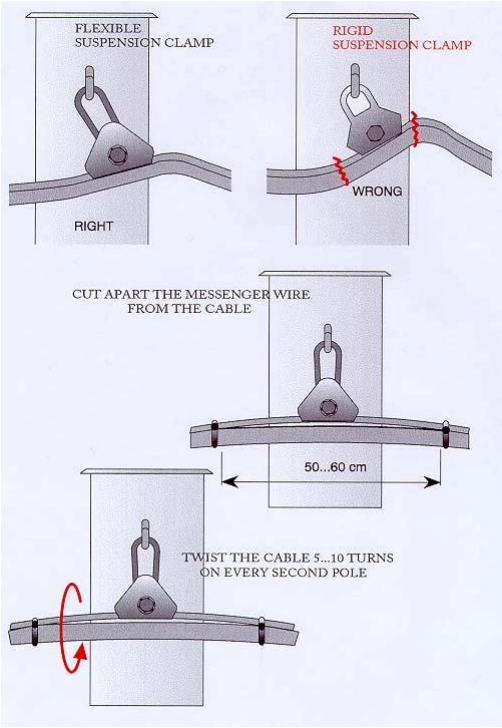
Installation "hints" for "figure 8" fibre optic aerial cable



GUIDELINES FOR INSTALLATION OF ADSS AERIAL OPTICAL CABLES

SCOPE AND PURPOSE

This guide provides general recommendations for the selection of methods, equipment, and tools for the stringing of All Dielectric Self-Supporting (ADSS) fibre optic cables.

The installation methods for ADSS cables are essentially the same as those used for installing power utility conductors.

However, special care must be taken in order to not exceed the maximum pulling tension, the minimum bending radius, and the maximum crush or impact resistance. It is also essential to avoid all jacket damage, since this can expose the strength yarns and significantly reduce the reliability of the cable. A more detailed explanation of these special precautions is discussed in this document. The IEEE Guide to the Installation of Overhead Transmission Line Conductors will provide additional relevant information about installation practices.

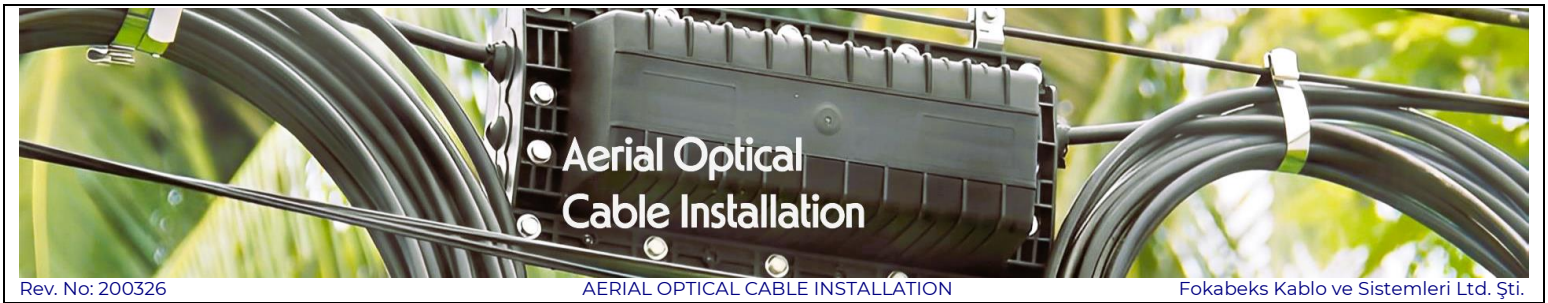
REFERENCES

- IEEE Standard 524-1992, Guide to the Installation of Overhead Transmission Line Conductors.
- NESC Safety Rules for the Installation and Maintenance of Overhead Electric Supply and Communications Lines.

SAFETY

All safety practices of the Power Utility and the Installation Contractor must be followed. These safety procedures will take precedence over any information contained in this document. Leakage current from the phase conductors can produce currents on the ADSS cable or hardware, especially during wet weather. It is important that all personnel and equipment are properly grounded, and that the cable is grounded before touching it. Do not install cables on energized towers during wet weather conditions.

Refer to section 43 and 44 of the NESC for maintaining safe distances from the phase conductors.



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CABLE PLACEMENT

In order to avoid high field voltages that occur close to the phase conductors, the position of the ADSS cable must be carefully considered before selecting where the cable will be installed on the towers. The most favourable location for installation on support structures is an area of relatively low field voltage, which can be determined by use of an electromagnetic field voltage calculation program. These calculations can be used to help determine the best place to install the ADSS cable.

ADSS STRINGING METHODS

The recommended method to install ADSS cable is the 'Stationary Reel' method. This method requires the reel of cable to be stationed at one end of a pull and a take up reel on the other end. A pull line is threaded through sheaves using a pull line of matched weight.

Care must be taken to avoid damage to the ADSS cable during handling and placing operations. It is critical to observe the cable's specified minimum bending radius and maximum pulling tensions. Precautions must be taken to avoid sharp bends or exceeding the recommended tensions.

Cable reels should be transported in an upright position, on the flanges only. Never lay the cable reel on its side. Inspect the reel flanges and ensure that the inner surfaces do not contain any and diameter. Once the pull line is threaded and all the sheaves are balanced/tied up, then the take up mechanism is started and the ADSS cable is pulled through the sheaves under tension.

The 'Moving Reel' method is not recommended for an ADSS installation because the pulling tensions and loading on the hardware are uneven. Also, it is difficult to keep constant tension on the cable in the suspension sheaves between tension points. Uneven tensions can cause damage to the jacket and create minimum bending radius violations.

ADSS cable installs similarly on distribution and transmission lines. Transmission lines require more precautions if the line is energized. If the line voltage is 230 KV or greater, grounding the sheaves may be required. The other main concern is the distance from the live conductors at the attachment points on the structure. Grounding of the hardware is recommended, but it is not permissible to clamp grounding hardware directly to the cable, as it may cause damage. Standard utility precautions should be used if the length of the tension hardware reaches close to the region of the conductor.

PRECAUTIONS

Splinters or nicks that could cause damage to the cable jacket when paying off.

Safety devices such as guard poles or mid span pulleys need to be installed for protection at all public roadways, utility lines, and railroad crossings. If crossing distribution lines, those lines need to have temporary insulators installed.

Survey the cable route before starting to ensure it is clear of obstructions. Do not allow the cable to drag on the ground or over obstructions.

The addition of any cable to an existing tower structure will increase their load. Tower or pole strength and guying requirements should be checked prior to cable installation.

INSTALLATION EQUIPMENT

Grips and Pulling Eyes: woven wire mesh (double or triple weave) type pulling grips are recommended to attach the cable to the pulling line. Ensure that the correct size grip is used for the cable.

Sheaves (Pulleys or Travellers): These must have a soft neoprene or similar material liner to cushion the cable from the bare metal of the sheave. The liner or insert must be smooth and show no signs of wear and tear. It is unacceptable for the sheave to have chunks of cushion missing or worn through at the bottom of the groove.

The depth of the groove should be at least twice as large as the cable diameter, and must be large enough to accommodate the swivel and pulling grips.

In some areas, it is necessary to use uplift rollers or hold-down blocks. This will keep the cable away from phase conductors and ensure that the cable stays in the sheave groove.

The sheave must be a single wheel construction. Multi-wheel 'banana' type sheaves often have shallow grooves that may allow the cable to jump out of the groove and are therefore not recommended. If sheaves are yoked together for a large angle change, the setup must be approved by Cable producer. The proper diameter sheave is specified by the cable diameter for each particular cable design. The rule of thumb is the sheave radius is equal to or greater than 20 times the cable diameter.

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Pulling Rope: The pulling rope must be dielectric and be well matched to the cable diameter and cable weight.

This will better prepare the sheaves in the system to balance the load as the cable is pulled and allow the cable to ride in the bottom of the sheave groove.

Tensioner: A bull wheel tensioner with a brake and tension monitoring equipment is required for an ADSS installation.This must provide a constant tension and be capable of a smooth acceleration and deceleration without causing the cable reel to overrun.

Puller with sufficient pull rope capacity: The puller should be equipped with a brake and tension monitoring equipment to keep constant tension on the cable as it is being installed.

CABLE HARDWARE

Typical cable hardware will consist of Tangent Clamps, Suspension Grips, and Tension Grips. Hardware is designed for specific cable designs. Only use hardware recommended for a given cable design, and never re-use hardware. It is important to carefully install the hardware without any damage to the cable jacket. Any cable jacket damage must be immediately reported, and if necessary, the cable must be replaced.

A Tangent Clamp is used as cable attachment hardware only on spans less than 100 meters when the angle of change, either horizontal or vertical, is less than 15°. The tangent clamp is designed to hold the cable in the air at the pole without gripping the cable as with a suspension grip (described below).

The tangent is typically designed to allow the cable to slip through the unit at uneven tensions resulting from unbalanced loads. There are several different approved suppliers of the tangent hardware, each with different designs.

An AGS (Armour Grip Suspension) Suspension is used for any span length with an angle change, either horizontal or vertical, of less than 25°.

An AGS Suspension Grip shall be used for in-line structures if the span is greater than 100 meters .

Tension Grips (Fibre Optic Dead ends) are used in several instances. A tension grip is installed at each end of the cable length to attach to the structures. Two tension grips are used at angle changes of 25° or greater, either horizontal or vertical. If the structures are in-line but have a vertical difference greater than 20°, tension grips shall be used to distribute the cable through the incline/decline.

TYPICAL PROCEDURES FOR STRINGING OPERATIONS

Installation Equipment Sites

It is important to pick the proper location for the pay-off and take-up equipment. The reel of ADSS cable (pay- off) must be located directly in line with the first sheave and must be back from the structure four times the height of the sheave (4:1 distance to height ratio). It is recommended to have at least three structures before the first large angle change. The equipment and ADSS cable reel should be in a safe and secure location, worry-free from vandalism or theft since the equipment could sit overnight.

Sheave Installation

Each structure in the pulling segment must have a sheave installed and a pulling rope threaded through it.

Each sheave must be balanced so that the rope, and later the ADSS cable, rides at the bottom of the neoprene insert's groove. It is important to tie up the sheave at each angle so the pulling rope and ADSS cable enter and exit the sheave smoothly. If the cable enters at an angle, it has a very good chance of jumping from the sheave groove into the space between the sheave and the yoke holding the sheave to the pole.

This would cause severe damage to the cable.

Pulling Lines

Once the sheaves are installed, the pulling rope shall be threaded (reeved) through the system. It is extremely important that the pulling rope and the ADSS cable have the same diameter and approximate weight. This will allow the sheaves to float at the same level with the pulling rope as they will when the ADSS cable enters the sheaves. It is important that the cable and sheave are in the same plane, to avoid any cable damage caused by contact with the edges of the sheave. The pulling line should be all dielectric and not be susceptible to internal, electrical

static charge buildup. The pulling rope should never be allowed to touch or drape over distribution lines or slump between pole attachments. It should have constant tension throughout the entire pulling operation.

Pulling the ADSS Cable

The ADSS cable shall be attached to the pulling rope using a double swivel eye and woven wire grip. Special attention must be paid to the grip and swivel as they pass through the sheaves and near the towers. The double swivel eye insures the ADSS cable will not see an induced torsion as the pulling line enters and exits each sheave. A 'flag' shall be attached just behind the swivel eye on the ADSS cable jacket. This flag should stay straight through each sheave. If the flag starts to flip over the cable, it shows the swivel eye is not working properly. If this is the case, the pulling operation should be stopped and the swivel should be oiled or fixed.

The woven wire grip shall be of a proper diameter and of sufficient length on the cable jacket to insure even loading of the cable strength members. The edges of the woven wire grip should be taped smooth so the grip does not damage the neoprene inserts of the travellers as it passes through.

The cable tension must not exceed the maximum installation tension recommended. Special attention must be paid to maintaining an even tension and speed. The wire mesh grips are designed to pull the cable, not to hold it under final tension. Do not use the wire mesh grips to apply the final tension to the cable.

Sagging

The ADSS cable shall be sagged from the pay-off (cable reel) end towards the take-up equipment, starting with the tension grip at the first structure near the cable reel. The sag can be adjusted using several methods. The recommended method is the 'line of site' method. This requires the sag distance to be determined ahead of time for each particular span length. One or more spans between tension grip locations should be checked using this method. After placing the cable under tension, it may be necessary to wait for approximately 24 hours for the cable to creep before making the final sag measurements.

The 'Line of Site' sagging method requires climbing both structures on either side of a span to be checked.

The structure closest to the pay-off end of the system is tensioned. Then the next structure is marked using bright coloured tape with the appropriate mid-span sag distance from the attachment height. The lineman returns to the pay-off end structure and measures down the mid-span sag distance and places his line of site at that same height. This person should have radio contact with the take-up operator and give instructions of how much to tighten the cable in the system so that the belly of the sag of this particular span rises to match the bright coloured tape mark on the opposite structure. Once the sag matches the requirement, the take-up side tension structure can be climbed and clipped in. The cable sag just after pulling should be looser than the required, clipped in sag. The belly of the sag shall always be brought up the proper sag, not loosened or brought down to the correct sag.

There are two methods of pulling the cable back to the structure to tension it. A temporary tension grip can be partially installed to supply a pulling loop, or an aramid yarn braiding pulling eye may be used. It is not acceptable to use a hoist, clamp, or other device not designed for fibre optic cables at mid-segment to temporarily pull the cable.

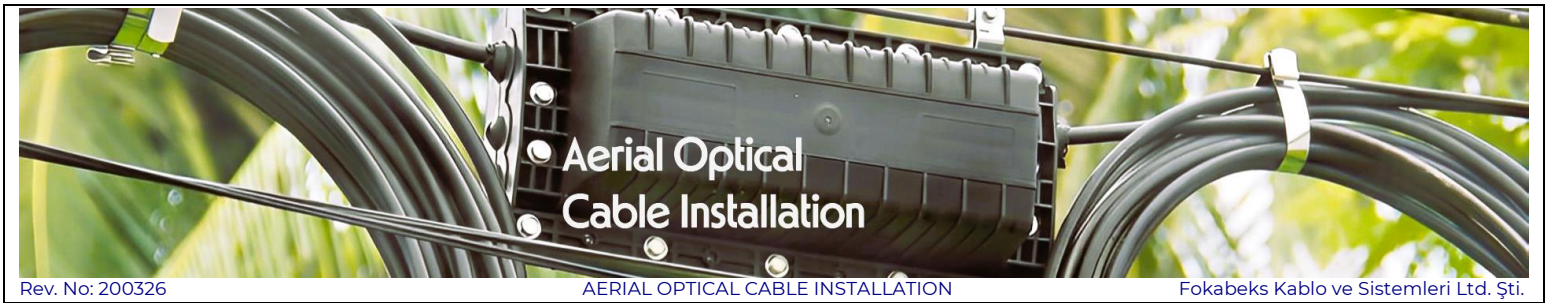
Clipping-in and Tensioning

The system segment shall first be sagged and tensioned at the appropriate structures. The tension grips shall have a sufficient drip loop between two tension grips on a structure to allow free movement. The tension grips shall be attached to the structure using an extension link (It is recommended using at least a 30 cm extension link) in order to get proper distance from the structure to allow the drip loop. The drip loop should be positioned downward and at least 30 cm deep. Next the AGS Suspensions and/or Tangents can be installed. The installing of the ADSS hardware (Tensions, Tangents and AGS Suspensions) shall be prompt. The ADSS cable shall not be allowed to sit in the sheaves more than one week (or less in bad weather).

Damper Installation

If the system requires Aeolian vibration dampers, they can be installed after the ADSS hardware is in place at each individual structure.

However, it is normally necessary for some type of vibration control. Please refer to your hardware supplier if there is concern about a potential vibration situation.



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Splicing

Splicing should be performed on the ground. The splice can then be stored aerially (recommend at least 6 meters off the ground), at ground level in a pedestal or cabinet, or underground in a hand hole or manhole. Sufficient length of cable ends should allow the cable to descend the structure and enter a splicing vehicle or splicing area. Each splice should have at least a small storage loop to allow the splice to be removed from the base of the pole to the splicing equipment if it can not be located close by. Six meters of cable shall be discarded from each pulling grip end to remove damaged or stressed cable. Then typically, each cable end should have at least 30 meters or more from the tension attachment, depending on the tower or pole size. Be sure to account for at least 3 meters of cable for the splicing operation.Cable

Down Guides should be used to attach the ADSS cable to the structure along the entire height. The number of clamps, type of clamps, and distance between clamps should be sufficient to prevent any cable.