Heavy Movable Structures, Inc.

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Lake Buena Vista, Florida

# "Aerial Cables/Droop Cables"

by

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# AERIAL CABLES / DROOP CABLES

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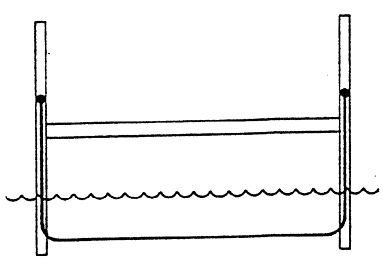
## Scope

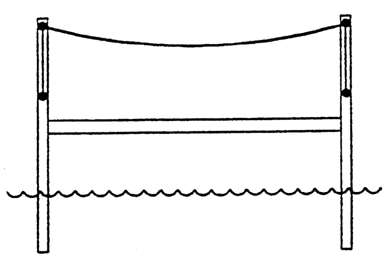
Transfer of electrical power, control, instrumentation, and communication is necessary between one side of a bridge and the other. Movable bridges over waterways make this task challenging since these cables have to travel either under the water or in the air. Most movable bridges will likely employ cables that are buried bene the bottom of the channel. These cables are usually trenched as much as 10 ft. to prevent ship or boat traffic from damaging the cable. Both the armored submarine cables and the installation of these cables are quite expensive.

Lift bridges or bridges that have significantly high towers on both sides allow for a choice of methods to conn both sides. While submarine cables may be used, aerial cables between the towers or droop cables would significantly decrease the installation and cable cost along with being able to sidestep many environmental issu that are claimed to result when disturbing the channel/seabed floor.

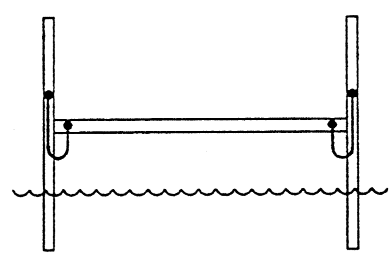
This paper discusses the various aerial cable designs, methods of attachment to the strength member (messenger), and tension calculations on the strength member. Additionally, the method employing droop cabl will also be discussed.



Submarine Cable



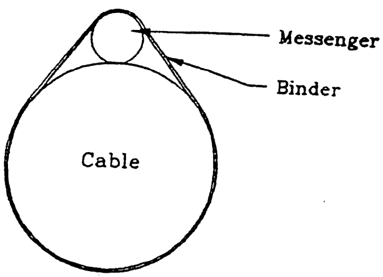
Aerial Cable



Droop Cable

## Aerial Cable – Parallel Messenger

The aerial cable employing a parallel messenger encompasses extra-flexible, rubber insulated conductors, whi are covered with a polyethylene jacket, laid parallel to a messenger, and bound with a metallic binder tape.




The conductors employed are always annealed or soft drawn copper and should be extra-flexible, class "K" stranding or higher which consists of 30 AWG (.010") individual wires. The purpose of employing this extra-flexible stranding is 1) promote improved flex fatigue life from movement due to vibration, swaying, an strumming and 2) improve flexibility for ease of handling and installation/terminating.

Either uncoated or tinned copper is used based on the customer preference; however, it is common for indust flexing cables to use only bare copper for sizes 8 AWG and larger (>6% improved conductivity). A separatoı tape is normally applied over the stranded conductor to permit movement between the insulation and the cop during cycling. This will also allow the rubber insulation to be easily removed from the conductor at the time termination with no remaining residue on the strand.

The insulation is a flexible rubber such as ethylene propylene rubber (EPR) which is a good dielectric materia must be ozone and heat resistant and meet the requirements of ICEA S-68-516, NEMA WC8, paragraph 3.7 Type II EPR. The Type II EPR has a 70% higher tensile strength requirement than Type I EPR (1200 psi vs. 700 psi) which provides improved impact resistance. The thickness of the EPR insulation is normally heavier than for static (non-moving) cables and is found in ICEA, table 3-1A, column A.

The insulated conductors are twisted or cabled together with a relatively short lay length. This causes the cab to be flexible and allows the strain on the copper conductors to be minimized when tensioned during and afte installation. Suitable moisture resistant, non-hygroscopic fillers such as multi-filament polypropylene or polyethylene and/or solid round rubber rods are employed in the interstices to make the cable cores round. C tapes are a composite rubber/fabric to prevent slippage of the overall jacket relative to the core.

The jacket should be black for resistance to sunlight, weather, and aging. To insure sufficient flexibility, the polyethylene jacket should be a low density, high molecular weight material. The reason a tough jacket, such polyethylene is used, is it's exceptional resistance to deformation from the metallic binder tape used to attach cable to the messenger. It is also a widely accepted material throughout the utility and transportation industry for continuous outdoor use.

The messenger employed is normally a flexible stainless steel Type 302, 304, or 316 aircraft cable. Cables employing strands in the form of 7 X 7 or 7 X 19 should be used rather than 1 X 7 or 1 X 19. This is due to their superior inherent rotation and torque resistance. Stainless steel Type 316 is only available with these strai constructions up to a diameter of 3/8". Stainless steel Type 316 provides superior resistance to corrosion in a seawater environment over the other two stainless steels; however, breaking strength is approximately 15% le: and it is not as readily available. Galvanized steel may be a less expensive alternative; however, if the galvanize coating becomes nicked and exposes the steel, corrosion occurs rapidly.

The jacketed electrical cable is attached to the stainless steel messenger by laying them both parallel to one another and wrapping them with an annealed stainless steel Type 302 or 304 binder tape. The binder tape is .020" or .025" thick and helically applied with a lay length of less than 6 inches. Traditional smaller aerial cabl employ either a copper tape or a galvanized steel tape as a binder. Copper tapes provide insufficient strength t safely support these heavier cables and can be easily torn during installation. The galvanized steel tape could b employed if extreme care is used during installation not to scrape the galvanizing and expose the steel.

The messenger size is governed by several factors that includes the weight of the cable & messenger, the horizontal span, the sag in the span, diameter of the cable, and the weather. Additionally, to maintain low strai on the copper conductor throughout all weather conditions, the proper size messenger is critical to the life of electrical core. Permanent elongation begins to occur on the copper conductors at approximately 0.35% elongation. Therefore a normal safety factor between the breaking strength of the messenger and the calculate horizontal tension on the messenger is a minimum of eight (8). The formula commonly accepted for this application is as follows:

## TENSION CALCULATIONS FOR AERIAL CABLES

$$T = \frac{L^2 W}{8S}$$

$$W = \sqrt{(w+i)^2 + h^2} + k$$

$$h = \frac{P\,(D+2t)}{12}$$

$$i = 1.25\,t\,(D+t)$$

T - Horizontal tension on messenger (lbs)

L - Span length (ft)

W - Total weight of cable when loaded (lbs/ft)

S - Sag in span (ft)

w - Weight of complete cable including messenger (lbs/

i - Weight of ice loading (lbs/ft)

h - Weight (force) due to wind (lbs/ft)

k - Constant, characteristic of loading district (lbs/ft)

t - Thickness of ice on cable (in)

P - Horizontal wind pressure (lbs/sq. ft)

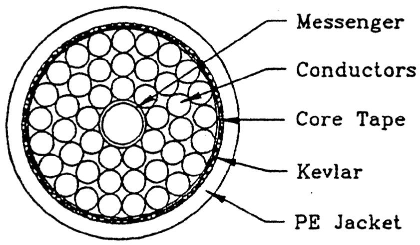
D - Diameter of cable (in)

## Loading Districts and Maximum Loading

| | Heavy | Medium | Light |
|---|---|---|---|
| t - Thickness of ice on cable (in) | 0.5 | 0.25 | 0 |
| P - Horizontal wind pressure (lbs/sq.ft) | 4 | 4 | 4 |
| k - Constant, characteristic of loading district | 0.31 | 0.22 | 0.05 |
| | Alaska | Alabama (Northern) | Alabama (Southern) |
| | Colorado (Eastern) | Arkansas | Arizona |
| | Connecticut | California (Northern) | California (Southern) |
| | Delaware | Colorado (Western) | Florida |
| | Illinois | Georgia (Northern) | Georgia (Southern) |
| | Indiana | Idaho | Hawaii |
| | Iowa | Kentucky | Louisiana (Southern) |
| | Kansas | Louisiana (Northern) | Mississippi (Southern) |
| | Maine | Mississippi (Northern) | Nevada (Southern) |
| | Massachusetts | Montana | New Mexico (Southweste |
| | Michigan | Nevada (Northern) | Texas (Southern) |
| | Missouri | New Mexico (Northern) | Wyoming (Northern) |
| | Nebraska | Oregon | |
| | New Hampshire | South Carolina | |
| | New Jersey | Tennessee | |
| | New York | Texas (Mid-East-West) | |
| | North Dakota | Utah | |
| | Ohio | Washington | |
| | Oklahoma | Wyoming (Southeastern) | |
| | Pennsylvania | | |
| | Rhode Island | | |
| | South Dakota | | |
| | Texas (Northern) | | |
| | Vermont | | |
| | Virginia | | |
| | West Virginia | | |
| | Wisconsin | | |
| | Washington, D.C. | | |

## Aerial Cable -- Central Messenger

The aerial cable employing a central messenger encompasses extra-flexible, rubber insulated conductors, cabl around a jacketed messenger, of which the finished cable core is covered with a polyethylene jacket.



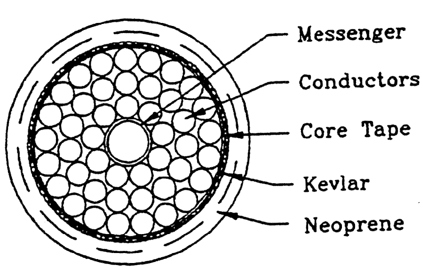

These cables employ the same insulated conductors, fillers, core tape, jacket, and messenger as the parallel messenger type aerial cable except the messenger is within the jacketed core and becomes an integral part of cable. The messenger will always have some type of covering over it prior to cabling the conductors around i This material may be an extruded thermoplastic rubber, soft polyvinyl chloride (PVC), or rubber/fabric tapes. These are applied so that the insulation is not damaged from direct contact with the uneven messenger surfac

Since these cable are installed by pulling on the outer jacket, a Kevlar reinforcement is recommended under t PE jacket. This provides the jacket with extra strength during handling, along with a measure of cut-through resistance.

## Droop Cables

Droop cables are used to connect a junction box on a fixed tower with a junction box on a moving deck of a horizontal lift bridge. The horizontal bridge deck is raised vertically with the cables maintaining their installe loop in the open or closed position. Other electrically equivalent cables may be employed across the bridge d and/or down the tower into the control/power room.

Droop cables employ extra-flexible, rubber insulated conductors which are cabled around a jacketed messen of which the finished cable core is covered with a Neoprene jacket.



These cable employs the same insulated conductors, fillers, core tape, and covered messenger as the central messenger aerial cable except with a reinforced Neoprene overall jacket. Neoprene is utilized because of it 's excellent flexibility, superior abrasion resistance, and high Modulas (resistance to dimensional change). The jacket is a black heavy-duty weather resistant Neoprene jacket in accordance with ICEA S-68-516, NEMA WC8. If the loop radius required is abnormally small, it may be necessary to adjust the cable design and materials.

Since these cable are permanently installed with pulling grips on the outer Neoprene jacket, a Kevlar reinforcement is recommended between the two layers of the Neoprene jacket. This provides the jacket witl additional tear strength, along with a measure of cut-through resistance.

## Discussion

Aerial cables for movable bridges normally encompass a significant number of conductors and quite often u: large conductors for power. These cables are typically 2.0" to 3.5" in diameter and are too large to be wrap around a messenger strength member (similar to service drop cables). Jackets that encompass both the cabl the messenger into a figure 8 configuration are not considered a secure enough method of attachment for th types of cables. The weight of the cable along with movement due to vibration, strumming, wind, etc. may the relatively small messenger to cut through the jacket.They must be laid parallel to the messenger and bou some fashion with an appropriate binder. The form of attachment to the messenger must also allow the cabl be separated from the messenger relatively easily during installation since the cable will extend beyond the mechanical termination points of the messenger.

The parallel messenger type aerial cable is relatively easy to separate the jacketed electrical core from the messenger after adequately anchoring it to the steel framework. Since these cables are terminated high on tl tower in a junction box, another cable is necessary to continue down inside the tower towards the control/n room. It is common to use the same jacketed cable which was suspended across the waterway, but without binder.

While all three cable types perform well once installed, the installation methods of both differ.

Since the jacketed electrical cable is attached with a continuous binder tape, care must be exerted during installation so as not to damage or severe the tape. Doing so would cause a section of the cable to separate it's intimate contact with the messenger and loop down. If this was to occur, special spring tensioned stainl steel clamps can be applied and act as a permanent binder.

Preassembly of the messenger to the jacketed cable is the only practical method of installation. Attempting install these cables to an existing installed messenger would not be feasible since suspending these heavy ca in the air, and applying a metallic binder, would be a logistical nightmare.

The central messenger type aerial cable would preferably be anchored to the steel framework within the tower away from direct exposure to the weather. This is because the outer polyethylene jacket would have to be removed so that the electrical conductors can be separated from the cable and brought into a junction box. Th transition section exposes the insulated conductors to the elements. These conductors would have to be cover with a modified shrink tubing to prevent water, etc. from entering the cable core area.

Another approach could be to have the junction box before the anchor point. In other words, the messenger would go through the junction box be affixed on the other side. This will allow the jacket to be removed in th junction box and the insulated conductors terminated within.

Paralleling several cables across the span at a relatively close proximity to one other may cause these cables t slap against each other due to crosswinds. Additionally, strumming may occur if there is a significant amount cable length and weight. In order to alleviate these occurrences, it is recommended that the cables be bound together with spacers in the middle 60% to 75% of the length. These Spacers are used to maintain the natural spacing between the cables when suspended across the span.

Droop cables would require a total of six (6) connection points (junction boxes) verses the four (4) normally used for the other two cable types. Droop cables are also more susceptible to vandalism since they are in clos proximity to the roadway or railway.

## Summary

Since there are several methods avaliable to transfer electrical energy across a waterway employing towers, many factors have to be considered by the bridge designer. Coast Guard regulations, County or State requirements, environmental issues, length of span, and cost of the entire project. Determining the number an size of the cables necessary requires good communication between the bridge designer and the cable manufacturer.