ELEVATOR TRAVELING CABLE - DESIGN EVOLUTION

by Richard Laney

Introduction

Elevator traveling cable is a vital link between the elevator car and controller. In conventional elevators, all power and signal information is transmitted through the traveling cable. The vast majority, as much as 95%, of wire and cable produced will be installed in a fixed location. The remainder will be used where some motion is required. Many of these cables are easily replaceable, with no serious consequence from any failure. The remaining flexible cables - in motion during service, such as mining cables, oil well boring cables, crane cables and elevator traveling cables - are expected to last. Elevator traveling cable is a specialized multi-conductor cable continually in motion and must last for many years. A generally accepted life span is 20 years - or 3,000,000 flex cycles.

Installation

Traveling cable is typically mounted in the elevator hoistway, where each end is terminated, and alternately takes the full load of the suspended cable as the car moves up and down. The hoistway termination may be in a mid-hoistway junction point (see Figure 1) or in the machine room (see Figure 2). Machine room termination is becoming widely accepted because it eliminates the junction box along with the labor and reliability issues associated with it.

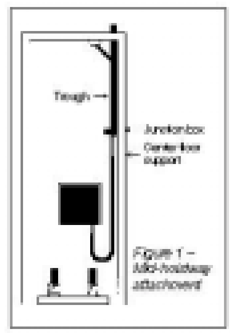


Figure 1 – Mid-hoistway attachment

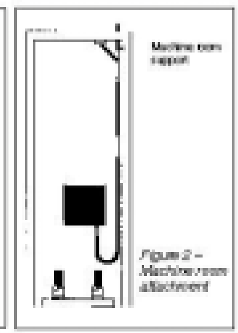


Figure 2 – Machine room attachment

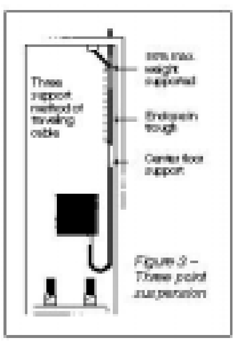


Figure 3 – Three point suspension

When terminating the cable in the machine room, the need to make electrical connections in the junction box is eliminated, but the resulting longer traveling cable may be more susceptible to trailing problems from building sway or wind. One intermediate installation technique terminates the traveling cable at the hoistway midpoint - using the steel support member - and continues to run the traveling cable to the machine room (see Figure 3). This eliminates labor required for mid-hoistway electrical terminations and restricts the free-hanging cable length. This method can be used for both round and flat type traveling cables.

The three methods for terminating traveling cable are by (1) an integral support member, (2) a self-tightening device or (3) looping the cable around a bar or spool and tying it to itself. Most electrical codes and standards require a suspended length or traveling cable exceeding 60 meters to be supported by an integral support member - most commonly a flexible steel strand. This is accomplished by wrapping the steel strand around a spool and clamping it back to itself (as shown for round cable in Figure 4 and for flat cable in Figure 5). Another device consists of an overall bracket for securing the cable with an integral self-tightening device for the steel support member (Figure 6).

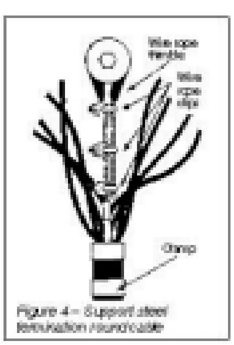


Figure 4 – Support steel termination round cable

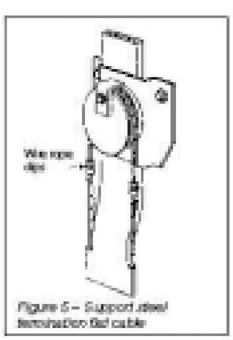


Figure 5 – Support steel termination flat cable

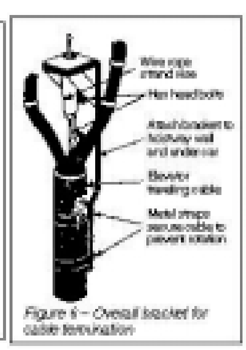


Figure 6 – Overall bracket for cable termination

Of the steel core termination methods, the steel core hanging device is the simplest to install. The hanger construction allows the wire rope to be inserted into the strand vise from only one direction, without allowing the rope to slip or pull out. Neither wrenches nor bending the wire rope are required. The strand vise automatically tightens on the wire rope for a secure termination. The wire rope strand vise is widely accepted for its ease of installation and reliability. The support bracket is designed to provide additional stability for the elevator traveling cable. The strand vise is inserted through the top flange to support the cable weight. The metal bracket extends down and is formed to cradle the cable below the strand vise support. Metal straps secure the cable to the bracket for improved lateral and rotational cable stability. With both ends secured, the cable can act as a cohesive unit during installation and operation under load.

Self-tightening devices generally support cables not requiring a support member - typically for cables with a suspended length of less than 60 meters. Self-tightening mesh grips are the most common termination means for round cable suspension (Figure 7). Wedge clamps are the most common termination means for flat cable (Figure 8).

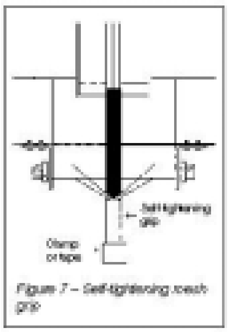


Figure 7 – Self-tightening mesh grip

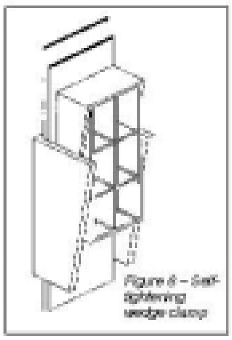


Figure 8 – Self-tightening wedge clamp

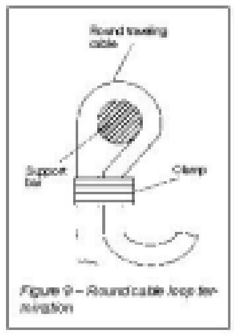


Figure 9 – Round cable loop termination

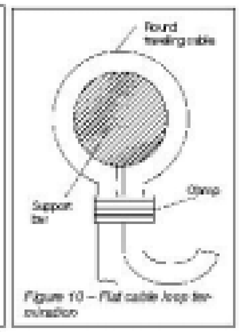


Figure 10 – Flat cable loop termination

Looping cables around a support bar or spool is allowed by some codes, and its use continues for cables with no support member, though this is the most unsatisfactory method for cable installation. The severe bends (Figure 9 and 10) in this type installation may cause stress points in the copper conductors, which will eventually work-harden and break as the cable undergoes cyclic loading. Draka Elevator Products does not recommend this installation technique.

Design Considerations

Some considerations in the design of the elevator traveling cable are cable strength, flexibility, torsional balance, abrasion resistance, flame resistance and low temperature performance. The cable must be designed for minimum strain on the copper conductors. A primary means to limit this is by use of a steel support member. The steel support is commonly used as a center member in a round cable and as integral support members in flat construction (Figure 11). In flat constructions, the support may be embedded in the plastic coating or as the support member of a group of insulated conductors.

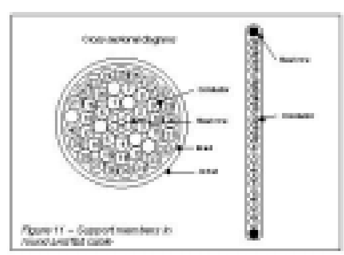


Figure 11 – Support members in round and flat cable

Cable flexibility is achieved by selection of materials used in, and the method of, cable construction. The copper conductors in elevator traveling cables are of a highly flexible construction. For instance, a $0.75mm^2$ conductor is actually constructed of 30 strands of 0.18mm diameter wire. The materials insulating the wires and overcoating the complete cable are formulated to aid flexibility of the product. Just as important are the construction techniques used to assemble the completed cable, whether round or flat.

Torsional balance is the tendency of a cable to untwist or turn under load and to reform into its original position when the load is removed. As an elevator rises, the cable section nearest the car-attachment point is exposed to greater and greater loads, until when the car is at the uppermost point, the car end of the cable is under maximum load. At this point, the hoistway end of the cable is under its minimum load. Cables with torsion generate vibration during travel. When the vibration becomes great, danger develops from problems such as the cables becoming tangled or cables becoming severed by contacting the wall, rail or car. As the elevator hoistway has become smaller in recent elevator constructions - due to the desire to provide maximum rental area in the building - and the space between the car and wall is narrow, minimizing vibration is important.

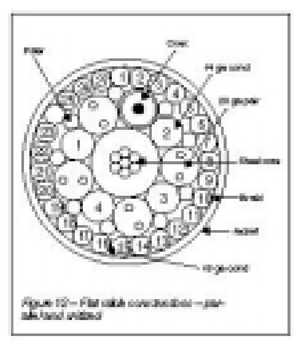
Different techniques are used to minimize the presence of torsion in elevator traveling cables. For round cables, a low torsion wire rope is selected for the central steel support member. In addition, the stranding direction of each layer of a multi-layered round cable is alternated. Finally, particular emphasis is placed on the mathematical ratio of conductor twist lay length to cable diameter to insure optimal cable performance.

Torsion is minimized in flat traveling cables by alternating the strand direction of multiple conductor subunits. When required, low torsion steel support members are placed in outboard positions and have opposite strand lays. Finally, proper handling throughout manufacturing and installation is essential to torsional balance in both round and flat configurations.

Abrasion resistance, flame resistance and low temperature performance are primarily addressed through the material used for insulating and jacketing the cable. Polyvinyl chloride is a widely used thermoplastic which has relatively good performance in these areas and is cost-effective. When special-performance characteristics are required, other polymers may be used for a specific application. In some cases, where extraordinary abrasion-resistance is needed, an outer polyurethane coating has proven effective. In some municipal jobs, halogenated materials are banned, requiring special polyolifin compounds be used to manufacture a halogen free traveling cable.

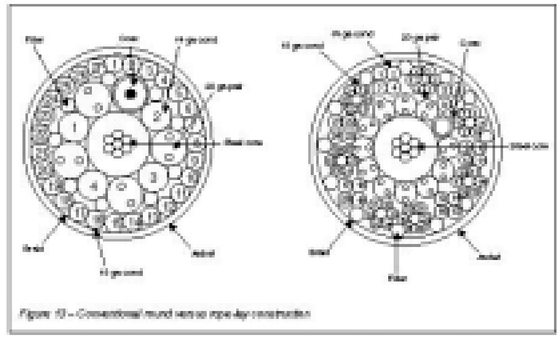
Product Design

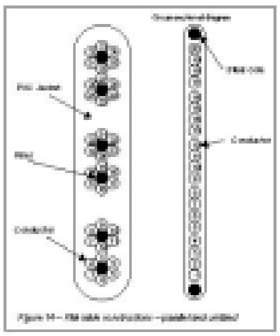
The traveling cable required for today's sophisticated elevators does not closely resemble cable of 25 years ago. The older cables contained, perhaps, 20-30 conductors of 16 AWG or $1mm^2$. Today's cables might contain a variety of wire sizes and components for specific purposes. A typical cable (Figure 12) will have 14 AWG ($1.5mm^2$) conductors for constant current-carrying circuits, 18 AWG ($0.75mm^2$) conductors for signaling circuits, 20 AWG ($0.5mm^2$) conductors with shielding for telecommunications circuits and data circuits, and perhaps a coaxial cable for closed-circuit television. Optical fiber's immunity to electrical and electromagnetic interference make it an excellent means for transmission of high-quality signals to and from the car. Optical fiber has proven to be very reliable in the flexing environment of elevator traveling cable with some installations over 10 years old.



Two basic types of traveling cable, already mentioned, are the round configuration and flat configuration. Round cable is typically composed of several layers of insulated conductors of components stranded around a central member. Round cables can contain a large number of conductors - as many as 120. The round construction offers great flexibility with regard to number and size of components that can be combined into one cable.

A variation on round cable is rope lay or unitized construction (Figure 13). This is manufactured by placing a number of small, round cable cores together to form one large cable. This construction has particular advantages in some special situations; for instance, with a relatively small loop, it could be use in space-constricted areas. Strength components can be added to the small unit cores, giving the finished cable increased overall strengths, which may be required if the cable travels over a sheave or is exposed to another extreme mechanical condition.





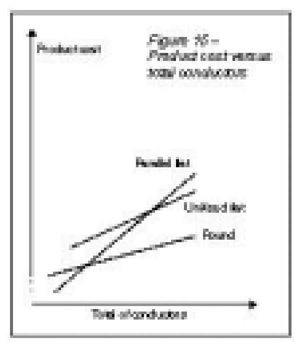
Flat cables can generally be classified as either parallel flat or unitized flat (Figure 14). The parallel flat is construction by laying conductors and/or components side by side and applying an overall jacket or sheath. For unitized flat cable, small round cable cores (as in the rope lay construction) are laid in parallel and covered with an overall sheath or jacket.

Flat or Round

Much has been discussed concerning round cable versus flat cable. Of the ongoing discussion, much revolves around the cost-effectiveness and application of the two constructions.

The product cost of the parallel flat is less than equivalent round-cable cost when a low number of conductors are required for a given elevator. Also, flat cables typically form smaller loops than their round counterparts. For these reasons, flat cables are often specified for lower rise applications and situations where loop clearance is minimal.

If multiple flat cables must be combined to achieve the proper number of conductors, a single round cable is more cost-effective when considering total installed costs. The unitized flat construction allows more conductors per flat cable but does not compare favorably with the equivalent round cable product cost. A general idea of product cost compared to total conductors required per unit is shown in Figure 15.



A single round cable can contain a large number of conductors thereby reducing the number of cables required per elevator. In addition, round cables have a smaller surface area than similar flat cables. These characteristics make round cables ideal for use in high rise, high speed applications.

Performance wise, each product serves a need in the marketplace, and in some cases, it is a matter of customer preference.

Special Considerations

Special consideration must be made for the high-rise segment of the market. These extreme conditions test the traveling cable to the fullest.

In some instances, 200-250 meters of traveling cable may hang free in the hoistway. These free-hanging cables oscillate with building motion and build up large amplitudes. Gaining energy from oscillation of building movement, they may become entangled with hoistway protrusion or compensation ropes experiencing the same phenomena.

Experience has proven that cable with a greater mass performs best in these high-rise environments. Round and unitized flat cables have provided excellent service in the high speed/high rise applications of today. Most notable is the Kuala Lumpur City Center which utilizes round cables for a 450-meter rise at 8.0 m/sec.

Conclusion

A number of elevator cable designs and installation techniques are available. The elevator contractor must work closely with the cable manufacturer's application engineers to insure the use of best product for the application.