# Structures and Selection of Wire Ropes for Elevators

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**ABSTRACT**

In the elevator installations, wire ropes are used to suspend the cars and the counterweights. Wire ropes in elevators are of round stranded and usually of right hand lay. Service life of elevator ropes depends on a number of factors such as wrap angle and lubrication. In this study types and structures of wire ropes are examined and compared. Then selection of elevator wire ropes is explained and service life of ropes is discussed in accordance with the standards.

## 1. INTRODUCTION

Wire rope is a hardworking and hard wearing piece of elevator drive unit. When it is used inappropritely and unqualifiedly this valuable commodity can not give of its best. For ist efficiency and long service life, the elevator's wire rope needs thorough care, maintenance and the use of the right rope for the job in hand. The development of the wire ropes is stimulated by and took place with development of elevators. Wire rope is an important aspect of continued reliable elevator operation. Elevator ropes are usually made with Bright or Uncoated wire, but they can be made with zinc Galvanized wire for corrosion protection.

## 2. STRUCTURE OF WIRE ROPES

Wire ropes are manufactured from steel wire with an ultimate strenght of 1600 – 1800 $N/mm^2$. In the process of manufacture, the wire is subjected to special heat treatment which is combined with cold drawing, to impart high mechanical properties to the wire. A number of wires are twisted around a centre wire to form a strand. The helical shape is made by the preforming process. After the strands are made a number of them, usually 6 or 8 are twisted around a wire or fibre core to make the wire rope. Figure 1 shows the apperance of a strand and a wire when they are removed from a preformed wire rope (Imrak, 1999).

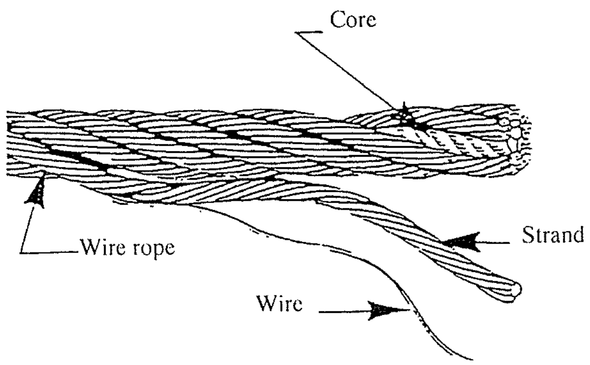


*Figure 1. The elements of wire rope*

The wires are provided with zinc protective coating for protecting them against corrosion. However, the loading capacity of a rope with galvanized wires is about 10 per cent lower due to the tempering effects of hot zinc coating (Küntscher, 1989). Wire ropes have got either fibre or wire cores which are made especially for their centres to support the strands around them (Figure 2). The prons and cons of the wire core in the centre of the rope instead of the usual fibre. Wire cores add to the strenght slightly, and increase the solidity very considerably, although they make the rope slightly stiffer (Dickie, 1975).

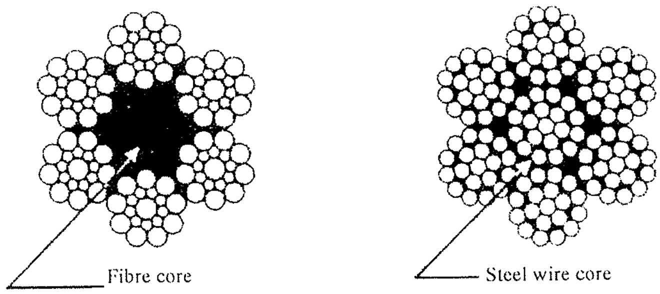


*Figure 2. The cores of wire ropes*

The two types of ropes which denote the direction of the wires and the strands are regular lay and Langs lay as explained in the following two subsections.

## 2.1. Regular Lay Ropes

In Regular lay ropes, the wires in the strands are twisted in one direction when making strands and the strands layed in the opposite direction when making the rope as shown in Figure 3. The main advantages of Regular lay ropes are their stability and handling ease owing to the good resistance to kinking and twisting.

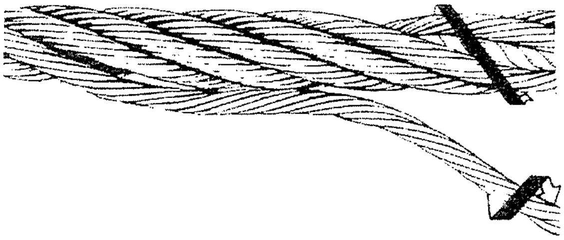

*Figure 3. Regular lay*

The special feature of these ropes is that each layer of wires in the strand is of the same lay length as the wires in its other layers. In Regular lay contsructions the outer wires fit into interstices between wires of inner layer of the strand. This construction is therefore sometimes referred to as Parallel Lay (Dickie, 1975).

The object of the equal laid rope is to arrange for the overlaying wires to rest in the gussets or the bed formed by two underlaying wires. This cannot be done haphazard, for there are only a few combinations which give the required result. These are known as the Seale, the Filler and the Warrington construction as shown in Figure 4 (Imrak, 1997b).

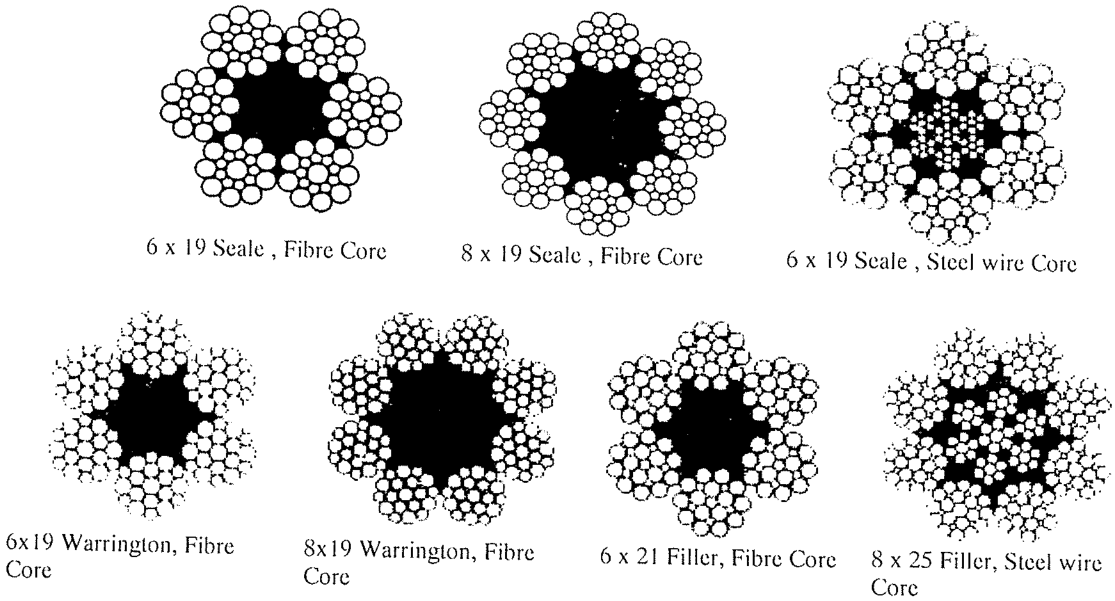


*Figure 4. Regular Lay rope constructions*

The Seale construction, which is used as a elevator rope, can be described as a number of large wires laid over an equal number of small wires, the larger wires resting in the gusstes of two of smaller wires beneath them. This construction is usually made, 9 wires over 9 wires over one. This is the most robust of its type, and when made into a 6-stranded rope is a popular choice for elevators. It may be a little stiffer than some of the other constructions but its advantages generally outweigh this point (Loney, 1990). As previously mentioned, the Filler and Warrington constructions are rather more delicate than the robust Seale, and except in the larger sizes of rope are therefore used on less strenuous plant, such as elevators (Küntscher, 1989).

## 2.2. Langs Lay Ropes

In Langs lay ropes, the wire in the strands and the strands in the rope are twisted in the same direction as shown in Figure 5. The main benefits of Langs lay ropes are their flexibility, fatique and abrasion resistance and long life due to greater contact surface leading to a lower unit pressure between the wires.Langs lay rope is generally preferred in cases where wear by loss of area has to be considered.

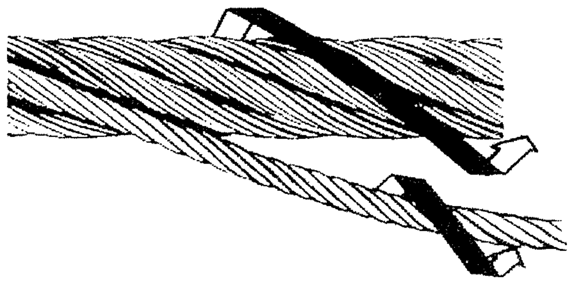

*Figure 5. Langs lay construction*

However, Langs Lay round stranded ropes must never be used where their ends are free to rotate, or the load itself can rotate. Langs lay ropes require more care in their installation on a plant, for some of the turns may tend to run out and lead to malformation of the rope or even permature failing (Dickie, 1975).

## 3. ELEVATOR WIRE ROPES

Considering the properties such as greater area of contact, flexibility and smoother running quality, it is recommended to use Regular lay ropes on elevators. Satisfactory traction was achieved using 8-strand ropes under conditions which cause 6-strand ropes to slip in the sheave grooves. Elevator rope diameter should be not less than 8 mm according to EN81 Standart, and not less than 9 mm according to A17.1 Code. In addition, steel core ropes are suggested to use on elevator installations. The point in favor of a steel core in elevator ropes are increased breaking strenght which could mean using ropes of a smaller diameter or increasing the car capacity, less stretch and less reduction in rope diameter which would mean less groove wear. Compansating and governor ropes are usually very light leaded, resulting in considerable rope vibration, as well as rotating and twisting in the sheave grooves.

### 3.1. Calculation and Selection of Wire Ropes

To calculate and select of elevator ropes, first maximum total rope force is calculated. Lifting load, car weight, rope weight and inertia force should be considered in maximum rope force calculation equation as given below (Imrak, 1999)

$$S_{max} = \left(\frac{Q+K}{z} + G_R\right)\cdot\left(1+\frac{b}{g}\right) \qquad (1)$$

where,

$Q$ : load ( $Q = 80 \cdot i$ ) [i : number of passengers]
$K$ : empty car weight [kg]
$G_R$ : rope weight [kg]
$z$ : roping factor
$b$ : acceleration of car [m/s$^2$] ( $b = 0.67 \cdot v^2 + 0.13 \cdot v$ )
$v$ : contract speed [m/s]
$g$ : gravitation 9.81 m/s$^2$

Maximum rope force which is acting one rope is found to divide maximum force to number of wire ropes (n), used to suspend the elevator car and the counterweight

$$S = \frac{S_{max}}{n} \tag{2}$$

To select rope from standard, minimum breaking load will calculated by means of factor of safety for rope. Minimum safety factor is selected according to the car speed from Figure 6 which shows minimum factors of safety for wire ropes given by A.17.1 Code (Janovsky, 1993). From EN 81 Standards minimum safety factors are selected as follows: (Barney et al. 1997)

$$F_B = S \cdot \upsilon \tag{3}$$

Traction drive with 2 wire ropes $\upsilon = 16$
Traction drive with more than 2 wire ropes $\upsilon = 12$
Drum drive $\upsilon = 12$

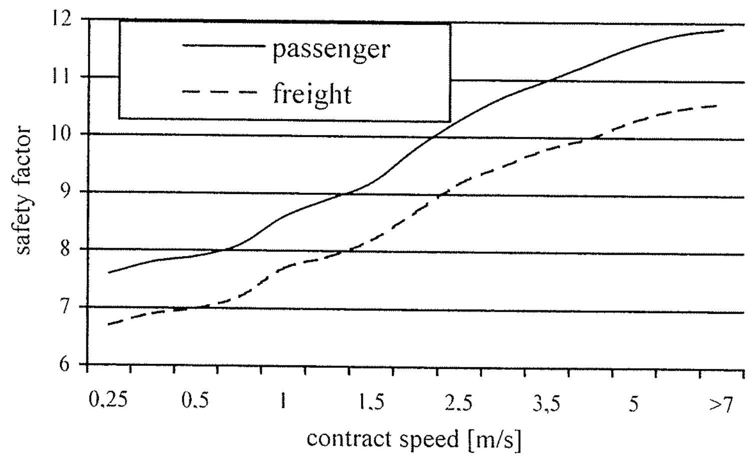


***Figure 6 Minimum safety factors for wire ropes according to A.17.1 Code***

Finally using Table 1 and Table 2 for elevator ropes which are given by Turkish Standards, elevator rope diameter will determine by means of minimum breaking load.

***Table 1. Minimum Breaking Loads For Seale Rope 6 x 19 construction (TS 1918/7)***

Fibre Core Ropes | Steel Wire Core Ropes

| Nom. Dia. [mm] | Approx. mass ≈ kg/m | Minimum breaking load [kN] Tensile grade [N/mm²] 1570 | Minimum breaking load [kN] Tensile grade [N/mm²] 1770 | Minimum breaking load [kN] Tensile grade [N/mm²] 1570 | Minimum breaking load [kN] Tensile grade [N/mm²] 1770 | Approx. Mass ≈ kg/m | Nom. Dia. [mm] |
|---|---|---|---|---|---|---|---|
| 8 | 0,238 | 38,7 | 43,6 | 44,9 | 50,6 | 0,262 | 8 |
| 9 | 0,302 | 48,9 | 55,2 | 56,8 | 64 | 0,332 | 9 |
| 10 | 0,373 | 60,4 | 68,1 | 70,1 | 79 | 0,410 | 10 |
| 12 | 0,537 | 87 | 98,1 | 101 | 114 | 0,590 | 12 |
| 15 | 0,838 | 136 | 153 | 158 | 178 | 0,922 | 15 |
| 16 | 0,954 | 155 | 174 | 179 | 202 | 1,05 | 16 |
| 18 | 1,21 | 196 | 221 | 227 | 256 | 1,33 | 18 |
| 20 | 1,49 | 242 | 272 | 280 | 316 | 1,64 | 20 |
| 22 | 1,80 | 292 | 330 | 339 | 382 | 1,98 | 22 |

*Table 2. Minimum Breaking Loads For Seale Rope 8 x 19 construction (TS 1918/18)*

Fibre Core Ropes | Steel Wire Core Ropes

| Nom. Dia. [mm] | Approx. mass ≈ kg/m | Minimum breaking load [kN] Tensile grade [N/mm²] | | Minimum breaking load [kN] Tensile grade [N/mm²] | | Approx. Mass ≈ kg/m | Nom. Dia. [mm] |
|---|---|---|---|---|---|---|---|
| | | 1570 | 1770 | 1570 | 1770 | | |
| 10 | 0,348 | 53,6 | 60,5 | 70,8 | 79,8 | 0,425 | 10 |
| 11 | 0,422 | 64,9 | 73,2 | 85,7 | 96,6 | 0,514 | 11 |
| 12 | 0,502 | 77,2 | 87,1 | 102 | 115 | 0,612 | 12 |
| 15 | 0,784 | 121 | 136 | 159 | 180 | 0,957 | 15 |
| 16 | 0,892 | 137 | 155 | 181 | 204 | 1,09 | 16 |
| 18 | 1,13 | 174 | 196 | 229 | 259 | 1,38 | 18 |
| 20 | 1,39 | 215 | 242 | 283 | 319 | 1,70 | 20 |
| 22 | 1,69 | 260 | 293 | 343 | 386 | 2,06 | 22 |
| 24 | 2,01 | 309 | 348 | 408 | 460 | 2,45 | 24 |

Secondly, wire rope elongation should be calculated as follows (Barney et al, 1997),

$$\Delta L = \frac{S \cdot L}{E \cdot A} \text{ [mm]} \tag{4}$$

where

S : the maksimum force [daN]
L : the rope length [mm]
A : cross sectional area of wire rope [mm²]

$$A = \frac{\pi \cdot d^2}{4} \cdot x \tag{5}$$

d : nominal diameter of rope [mm]
x : fullness factor of sectional area of rope
for 6 x 19 Seale rope x = 0.49
for 8 x 19 Seale rope x = 0.435
E : Young's Modulus (for Seale rope E = 6300 daN/mm$^2$ )

Acceptable rope elongation values are,
For lightly loaded ropes % 0.25
For normally loaded ropes % 0.5
For heavily loaded ropes % 1.0

## 4. LUBRICATION AND ITS EFFECTS ON WIRE ROPES

When the rope is being manufactured, the fibre core which forms the essential support upon which the strands rest, is thoroughly impregnated with lubricant; both the strands and the completed rope are also well lubricated. The lubrication is just as important a component as the wires and the cores. The bearing pressure of the rope components are directly related to the load on the rope. The need for a lubricating film between all contacting rope compenents should be very evident. The lubricant minimizes wear between wires. Every wire is thoroughly coated with a special elevator rope lubricant. (Janovsky, 1993).

Each time the rope in operation bends or straightens under load, relative movement takes place between wires, strands and core in the rope, as well as between the rope and the sheave groove. Frictional loses resulting from the rope operation must be kept to a minimum by effective and regular lubrication. The rope manufacturer should lubricate the rope and its core with correct grade and quality of lubricant (Loney, 1990).

A periodic application of suitable oil or grease must be made to ensure sufficient continuous lubrication. Inadequate lubrication can result in corrosion, heavy abrasive wear of the rope. In unfavorable enviromental conditions, where corrosion becomes a factor in rope operation, additional care and attention are important. The lubrication also reduces fatique because it allows correct movement of the wires with respect to each other. Areas of wear that can be reduced by effective lubrication are wear on outer rope wires caused by rubbing contact with sheaves and, internal wear caused by rope wire rubbing together during the flexing of the rope (Imrak,1997b).

Good rope lubricants are specially formulated for specific stresses and deteriorating factors affecting rope service. The lubricant should be fairly thin with good penetrating ability For traction drives the proper elevator rope lubricants are compounded to give anti-slip properties as well as good lubrication. When lubricating inside the rope, fine liquid grease with kolloid graphite is preffered. Rope lubrication grease must not contain bitumen and hydrocarbon. For traction elevators, rope lubricants are compunded to give antislip properties in addition to lubrication (Dickie, 1975).

The frequency of lubrication depends on many factors such as enviromental and temperature conditions, rope speed, type of elevator service, and only inspection can determine this frequency. Wire rope should be cleaned regularly with a wire brush and given a light lubricant dressing. This lubricant deters corrosion, repels water and puts a protective film on each individual wire. For rope being rested, the entire length should be cleaned with a wire brush and coated with a film of lubricants, before being coiled or reeled for storage.

## CONCLUSIONS

In modern elevator systems, steel wire ropes are used to suspend the car and the counter weight. The responsibility of proper wire rope selection and application for an elevator installation requires using the material that is economical and safe. In selecting wire ropes of an elevator, it is obvious that experience is very important. Some guidelines, however, can be set out to simplify the decision of wire rope selection. Although the rope strenght is of major importance, it is only one of the decision factors. It is recommended, therfore, to use the ropes of the correct size, grade, construction and type as advised by the rope or elevator manufacturers.

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