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INVESTIGATION ON ELEVATOR LOAD TRACTION COMPONENTS SUBJECTED TO AXIAL LOAD

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Abstract:
Elevator structures have been utilizing to help human life more comfortable. It provides transportation between floors in multi-storey buildings. An elevator serves in buildings with two or more floors. Elevator car, which is oriented by guide rails, is utilized for transportation of passengers or other loads entered into car. Elevator car and counterweight are suspended by means of traction components such as steel wire ropes and belts. Steel wire ropes and belts are used as load carrying member in the elevator systems. Elevator systems are exposed to external loads while performing their duties because of entering passengers or goods into elevator car. Stresses and elongations occur in accordance with those external loads. In this study, mechanical properties and maximum lifting capacities of innovative rope and belt samples have been determined by using tensile testing machine and compared. Two different kind of samples have been used. One of which is elevator rope with 6 mm in diameter and second is elevator belt having 50 mm width. It has been concluded that the investigated elevator belt carries much more load than the rope.

Key words:
Elevator belts, elevator ropes, tensile testing, tensile stress

1 INTRODUCTION

Effective elevators have to be a high availability, a comfortable ride and an economy in operation. Passengers must feel safe and the ride they experience must reassure them Elevator safety mainly depends on the strength of its load-bearing parts. Wire ropes and belts are the main load carrying components of elevators (Barney and Loher, 1990).

Steel wire ropes are made of high strength thin steel wires that are twisted around a core in order to constitute a strand. Then, constituted numerous strands are wrapped again to form a rope. There are many different types of ropes in the rope literature for the special application area such as crane, mining and marine industries (Onur and İmrak, 2011). On the last decade polyurethane coated elevator belts have been used as an alternative to steel wire ropes in the elevator systems. The main reason is that steel wire ropes have some important deficiencies in the system on the side of corrosion and lubrication. Elevator belt usage brinks low traction noise, lightweight, small bending radius and lubrication-free application (Shao et al., 2021). In the application area, steel wire ropes and belts are mainly subjected to axial tensile load. Therefore, it is very important to know the endurance limit values that the ropes and belts can lift. Those values correspond to safety factors in service.

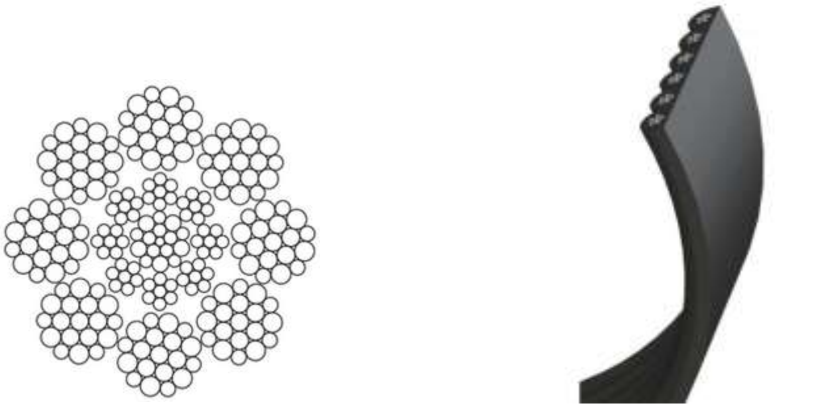
Various researches have been conducted to investigate mechanical behaviour of steel wire rope and belt under external load. Feyrer (2015) published a book which includes profound information, experimental and theoretical results for a wide variety of steel wire rope construction. Youssef et al. (2022) performed static tensile test on 19x7 wire rope to reveal endurance limits of investigated rope. Guo et al. (2022) conducted static tensile tests of locked coil wire rope under elevated temperature. Demiröz et al. (2015) investigated usage of belt driven elevators and their comparison with traditional rope driven elevators. Shao et al. (2021) introduced the structural characteristics of traction elevator belts. Lei et al. (2012) presented an inspection and health monitoring method for coated steel belts in an elevator system. Meknassi et al. (2016) investigated corrosion behavior of 19x7 wire rope construction immersed in 30% sulfuric acid solution. Chouairi et al. (2014) investigated the change in the tensile stress of the rope by creating different numbers of wire fractures on a 19x7 standard steel rope with 6 mm diameter. Aycan and Onur (2017) investigated changes in the axial lifting capacities of the damaged rope samples in the laboratory environment depending on the time and damage type. The most critical damage type for 6x19 Standard rope was determined as corrosion. In this study, two different types of traction member of elevator have been investigated. Mechanical properties and maximum lifting capacities of innovative rope and belt samples have been determined by using tensile testing machine.

2 METHODS AND METHODOLOGY

Steel ropes have been designed in such a way that they can fulfil all the required conditions for elevators. More recently, belts have also been used in elevators. It can be accepted as a new beginning for the elevators industry. Due to their elastic structure, they have bending and twisting capabilities as desired. Although their diameter is small, their tensile strength is extremely high. One of the most important issues to be considered in the operational safety of elevators is the tensile strength of the lifting element such as rope and belt.

Belts, which are the most important equipment of new generation elevator systems, have many advantages due to their structure. Polyurethane coated elevator belts do not require any additional lubrication and it makes the system cleaner for the environment. The polyurethane coated elevator belt minimizes metal-to-metal friction effects and thus wear-out, corrosion and friction in conventional systems. This creates a quieter working environment (www.ultraelevator.com.tr).

In this study, two different types of traction member of elevator have been used. First traction member investigated is steel wire rope which has diameter of 6 mm. Rope type investigated has 8x19 Warrington (W) composition. It has 8 strands helically wrapped around a steel core. It is called as innovative elevator rope in the industry since conventional elevator rope diameters are greater than 8 mm. Despite its very small diameter, the examined rope does not lose its safety due to its relatively large metallic cross-sectional area. At the same time, there is no decrease in flexibility due to its thinner wire composition. Elevator rope and belt investigated have been depicted in Figure 1.



(a) 8x19W rope *(b) Elevator Belt*

Fig. 1 *Investigated elevator rope and belt*

Technical properties of 8×19 Warrington rope and elevator belt investigated have been given in Table 1.

Tab. 1 *Technical properties of investigated steel wire rope and belt*

Rope diameter	6 mm	**Belt width**	50 mm
Rope composition	8x19W	**Belt thickness**	4.50 mm
Rope lay direction	Right	**Number of rope inside**	20
Tensile strength of rope wires	1770 MPa	**Belt material**	Polyurethane
Rope metallic cross sectional area	18.50 mm^2	**Surface**	V Groove

3 EXPERIMENTAL STUDIES AND RESULTS

In this study, steel wire rope and polyurethane coated elevator belt have been investigated. Rope and belt samples were prepared for the tensile testing. The free lengths between jaws on the tensile testing machine are determined by means of diameters of the ropes used in the tests in accordance with standard TS EN 12385-1+A1 (2010). The smallest free length of samples are given as 300 mm for ropes with a diameter of 6 mm and belt specimen lengths are 600 mm. The samples were cut on the grinding machine, taking into account the free lengths between jaws and the length of the end terminals. Tensile tests are conducted in accordance with TS EN ISO 6892-1 (2020). Hydraulic tensile testing machine with 600 kN capacity was used. Elevator rope and belt samples connected on the tensile testing machine have been shown in Figure 2.

(a) Steel wire rope

(b) Elevator belt

Fig. 2 *Steel wire rope and belt samples connected on tensile testing machine*

Each test was repeated twice and average of results were presented. Tensile stress, tensile endurance and elongation at break occurred on 8x19W elevator rope have been presented in Table 2.

Tab. 2 *Experimental tensile testing results for 8x19 Warrington rope*

Sample Name	**Tensile stress (σ_{max})**	**Tensile endurance (F_m)**	**Elongation at break**
8x19W steel rope	1394.59 MPa	25.80 kN	15 mm

Tensile test results indicate that maximum tensile stress occurred on 8x19W rope is 1394.59 MPa. Tensile endurance is 25.80 kN and elongation at break is 15 mm. Tensile stress, tensile endurance and elongation at break occurred on elevator belt having 50 mm width have been presented in Table 3.

Tab. 3 *Experimental tensile testing results for elevator belt*

Sample Name	**Tensile stress (σ_{max})**	**Tensile endurance (F_m)**	**Elongation at break**
PV50 belt	403.18 MPa	69.55 kN	14.70 mm

Tensile test results indicate that maximum tensile stress occurred on elevator belt investigated is 403.18 MPa. Tensile endurance is 69.55 kN and elongation at break is 14.70 mm.

Maximum tensile stress, tensile endurance and elongation at break occurred on 8x19W elevator rope and elevator belt having 50 mm width have been presented in Figure 3.

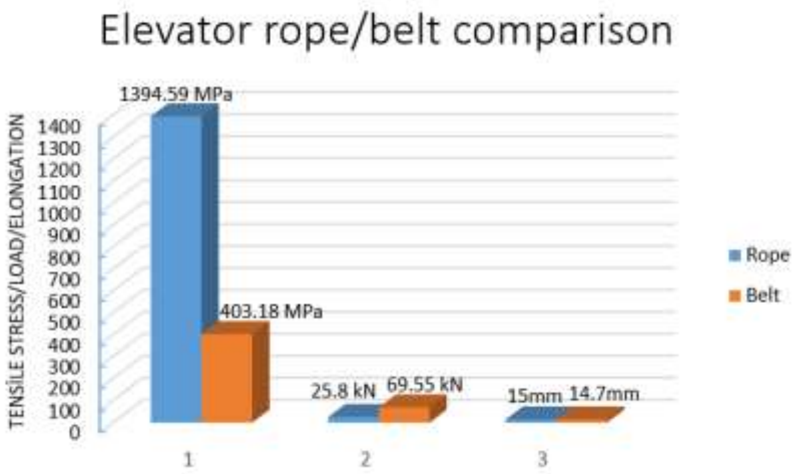


Fig. 3 *Tensile test results of investigated rope and belt*

Although elongation at break of both samples is almost equal, their tensile stress and tensile endurance values differ from each other. It has been determined that the elevator belt investigated can carry 2.69 times greater load than the investigated rope. In addition, the tensile stress occurred on the rope is considerably higher than that of the belt investigated. The difference in tensile stress and tensile endurance is due to being the cross-sectional area of the belt greater than the cross-sectional area of the rope.

4 CONCLUSIONS

In this study, mechanical properties and maximum lifting capacities of innovative rope and belt investigated have been determined and compared. Results indicate that elevator belt having 50 mm width has 69.55 kN lifting capacity and 8x19W rope has 25.80 kN lifting capacity. It has been concluded that the investigated elevator belt carries much more load than the rope. The tensile stress occurred on the rope is considerably higher than that of the belt investigated. Results gathered enable to reveal mechanical properties of two different types of traction member of elevator system.

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