ASSESSMENT OF THE CABLE FREIGHT CABLEWAY QUALITY

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Abstract

The paper deals with assessing the quality of the cable freight cableway in a chosen company. The main reasons for assessing the quality of the cable are unexpected damage and deformation of the cable in operation. The carrying cable from the branch of empty wagons of the cableway is considerably worn down in operation. Two samples were submitted for the tests of the cable from the branch of empty wagons. The first sample was new and the second sample was collected directly from operation. The microscopic documentation of both cable samples with appropriate parameters and attachments is described in detail in the article. The cable testing procedure is further elaborated. In conclusion, identified test data and quality data of the carrying cable are summarized.

Keywords:
burst test, deformation of wire ropes, carrying cable quality, microscopic analysis of cable

1. INTRODUCTION

This article is developed to assess the quality of the carrying rope of freight cableway transport. The carrying rope from the branch of empty wagons is considerably worn down. It was necessary to insert a rope coupling to prevent rupturing of the carrying rope.

Fig. 1 Samples of the ropes - Rope No. 1, Rope No. 2 Fig. 2 Samples of the ropes - Rope No. 2, Rope No. 1
Two ropes were provided for the analysis, both approximately 30 cm long (Fig. 1 and Fig. 2). The outer layers of rope No. 1 contained 22 wires and of rope No. 2 contained 20 wires. The inner layers were identical (number and diameter), they sequentially consisted of 18, 12, 6 and one central wire.

2. DESCRIPTION OF THE TEST ROPES

Two samples of the carrying rope from the branch of empty wagons were submitted for the tests. The first sample was taken from a new rope and has been designated as sample No. 1 for the purposes of testing. The second sample was taken from a rope from an existing operation and has been designated as sample No. 2 for the purposes of testing. The relevant documentation of the rope was provided together with the rope and received by the orderer upon delivery of the rope. Table 1 describes the basic parameters of the rope according to the supplied documentation [1].

Table 1 Parameters of the rope according to the supplied documentation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal diameter of the rope</td>
<td>Ф 22.4 mm</td>
</tr>
<tr>
<td>Construction</td>
<td>(1+6+12+17Z)</td>
</tr>
<tr>
<td>Number of strands</td>
<td>1</td>
</tr>
<tr>
<td>Transport drum</td>
<td>Unidentified</td>
</tr>
<tr>
<td>Inspection certificate No.</td>
<td>No. 3.1 from 25.8.2010</td>
</tr>
<tr>
<td>Serial No. of the rope</td>
<td>Unidentified</td>
</tr>
</tbody>
</table>

Table 2 describes the basic detected parameters of the cable.

Table 2 Parameters detected during the tests

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal diameter of the rope</td>
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<tr>
<td>Construction</td>
<td>(1+6+12+Z22)</td>
</tr>
<tr>
<td>Number of strands</td>
<td>1</td>
</tr>
</tbody>
</table>

3. THE TEST PROCEDURE AND THEIR EVALUATION

To determine the cause of damage and unexpected deformations of wires, it was decided to implement the following four tests:

1. Destructive - bursting test of the wires from the intact rope sample,
2. Destructive - bursting test of the wires from the impaired rope sample,
3. Metallographic test of the wires from the impaired part of the rope,
4. Fractographic test of the wires in the impaired sections.

The provided rope samples were unraveled and all the wires of the two samples were tested for pulling, bending, torsion and determining the dimensions of the cross section of the wire. Part of the impaired and part of the intact wires were subjected to metallographic and fractographic tests. Results of the destructive
test of the wires from the intact rope sample (from the new rope) and the results of the destructive test of the wires from the impaired part of the rope (rope from operation) are included in the test protocols of Steel ropes testing laboratory FBERG TU in Košice.

During the mechanical tests, it was found that the rope has a construction of 1 +6 +12 +18 + Z22. This fact was not mentioned in either document supplied with the rope. The Declaration of Conformity supplied with the rope states construction (1 +6 +12 +17 Z). The Declaration of Conformity states that the wires have strength of 1270 MPa. In the certificate by the attributed manufacturer of the rope, it is indicated that the rope is made of wire strength of 1 170 MPa. The orderer of the review required in the order to use methodology for destructive testing and evaluation of the rope under ÖNORM M9502, because of the quality requirements of the rope user. Destructive testing of rope samples were made under ÖNORM M9502. Parameters of corresponding strength of 1 370 MPa were chosen for the number of torsions and bendings because the mentioned norm did not contain the standard strength class of 1 270 MPa [2].

We can conclude, from the accompanying test reports of the destructive testing and metallographic tests and from the findings in these protocols, the following:

1. The supplied rope with its parameters of wire strength does not correspond ÖNORM M9502. Wires of the „Z“ layers have strength of 1 170 MPa and do not correspond with the rope strength class of 1 270 MPa. Wires of the „Z“ layer were excluded from the load capacity of the rope in both tested samples. Therefore, the sample of the new intact rope did not comply with the test.

2. Similarly, the rope sample from service did not comply with the test. Cracked wires on the top „Z“ layer and a lot of surface were identified before the destructive test on this rope sample.

3. It was found by metallographic tests that the wires are not of bainite structure and the wire surface is decarburized. Discrepancy in the parameters given in the documentation of the rope and the actually identified parameters of the rope was found during the testing of both rope samples [2].

The relevant graphical supplement describes: „the microscopic analysis of ropes“, which contains metallographic and fractographic analysis of the wires. The following facts have been found by macroscopic studies, i.e. significant bruising of one side of the rope No. 2 was found and a network of fine cracks stretches along the ropes No.2 in the position of the bruise. The size and the composition of the ropes are the same; however they differ in the number of external wires (rope No. 1-22, rope No. 2-20). Two outer wires of the rope No. 2 were plucked, precisely at the location of cracks. It can therefore be assumed that the cracks were the initiator of the damage. The microstructure of rope wires is predominantly pearlitic with a ferritic network; the grains are elongated in the direction of the wire axis. Decarburization of the surface was observed in the location of the wire edges. Hardness of the wire is approximately 370 HV 0.1 and it is 270 HV 0.1 in the decarburized parts. Neither the microstructure of the wires nor the measured hardness values correspond with the patented wire commonly used in the manufacture of ropes [3].
Fig. 3 Rope No. 2  Fig. 4 The torn off wire from another part of the rope No. 2

Fig. 3 shows rope No. 2 with the torn off and bruised wire, caused probably due to the missing wire. A piece of a torn off wire was supplied from another part of rope No. 2 (Fig. 4) beside the two ropes.

Fig. 5 Rope No. 2  Fig. 6 Rope No. 2, bruised side

It was discovered by macroscopic observation that rope No. 2 is more bruised on one side than on the other side (Figures 5 and 6).

Fig. 7 Stretch of crack on the bruised side  Fig. 8 Cracks on the bruised side
A band of fine crack stretches along the bruised side of the rope (Figures 7 and 8).

The fracture of both wires of rope No. 2 was located at the site of occurrence of such cracks. No significant external bruising was observed on rope No. 1.

Bruises on the wires of all layers were observed after unraveling the ropes into individual wires. Significant bruising was observed on wires of rope No. 2.

![Fig. 9 Rope No. 2, fracture 1](image1)

![Fig. 10 Rope No. 2, fracture 1](image2)

Fractures of the wires of rope No. 2 are documented in Figures 9 to 12. Localization of the fracture at the site of surface cracks of the wire can be seen in the images.

![Fig. 11 Rope No. 2, fracture 2](image3)

![Fig. 12 Rope No. 2, fracture 2](image4)
4. CONCLUSION

Based on the findings, we can conclude that the supplied rope does not meet the parameters required by the client and the user of the rope and ÖNORM M9502. The results of metallurgical analysis were confirmed by mechanical testing, where the wires from the ,,Z“ top layer with their strength class do not match the required class of 1 270 MPa and from the structural point of view, they can be considered as soft wires, decarburized. These negative characteristics of the rope wire caused a reduction of the carrying capacity and low reliability in operation reflected as visible deformities on the rope. We can assume an overall low life of the rope based on the identified parameters of the rope. The declaration states other structure of the rope (1 +6 +12 +17 Z) as was found in the tests (1 +6 +12 +Z22). Based on the results of mechanical tests and metallographic and fractographic expertise, it is recommended to exclude the rope from operation as soon as possible.

ACKNOWLEDGEMENTS

This article is part of the solution grant project VEGA 1/0922/12.

REFERENCES

[1] INTERNÝ MATERIÁL SKÚŠOBNE OCEĽOVÝCH LÁN V KOŠÍCIACH – Protokol ako príloha k posudku, vypracovaný na základe normy STN EN/ISO IEC 17025