In-situ non-destructive assessment of a haulage rope in a monocable zigback passenger ropeway

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Non-destructive testing is the only means for assessment of haulage ropes in terms of local faults (LF) and loss in metallic area (LMA). In a monocable ropeway, usually the cabins for passengers are connected through automatic grips or fixed grips with the haulage rope. In the present study, the monocable ropeway is so designed and utilised that there are two cabins for passengers in zigback arrangement, ie one going upwards to the UTP (upper terminal point) and simultaneously the other moving downwards to the LTP (lower terminal point). This paper evaluates and monitors the condition of a 6X19 Seale haulage rope in a monocable zigback passenger ropeway by a non-destructive assessment method.

Keywords: Haulage, non-destructive method, flaws.

Introduction

There is an obvious need to perform tests on the integrity of haulage ropes without in any way impairing their function[1]. Apart from careful visual examination and measurements of external diameter, non-destructive test methods have been extensively used.

Wire rope consists of wires, strands and core. A predetermined number of wires of proper size are fabricated in a uniform geometric arrangement of definite pitch or lay to form a strand. The required number of strands are then laid together symmetrically around a core to form the rope. Fibre cores are generally made of polypropylene or a hard fibre such as manila or sisal. These cores are adequate to provide the necessary foundation as well as the pliability of a wire rope.

There are two types of stretch that usually occur in wire ropes[2]. These are (1) constructional stretch (or permanent stretch) and (2) elastic stretch (or load stretch). Constructional stretch occurs due to the wires within the rope bedding in. The rate and degree of this stretch varies according to the type of rope, load on the rope and sag of the rope. New ropes stretch more. Stretch decreases throughout the rope's useful life and increases again at the time of wear. It is difficult to predict constructional stretch. Stranded ropes with a fibre core generally stretch 0.25-0.75% depending on the load on ropes. Elastic stretch is the stretch induced by a change in rope end load.

Lang's lay ropes have the wires in the strands laid in the same direction as the strands in the rope. Right-hand Lang's lay (Figure 1(a)) shows the final twisting of strands in the rope in the right hand direction *ie* strands laid right and wires laid right. The lay length of a rope is the distance parallel to the axis of the rope in which the outer strands make one complete turn (or helix) about the axis of the rope.

The design arrangement of the component parts of the wire rope is called the construction. A '6 by 19' rope has six strands with nineteen wires per strand. In Seale construction, each strand consists of three rings of wire. The first ring of wires around the centre wire of the strand is of smaller diameter than the centre and outer wires. Seale construction is a parallel strand construction with the same number of wires in each wire layer, each wire layer containing wires of the same size, for example 7-7-1; 8-8-1; 9-9-1.

Instrument used

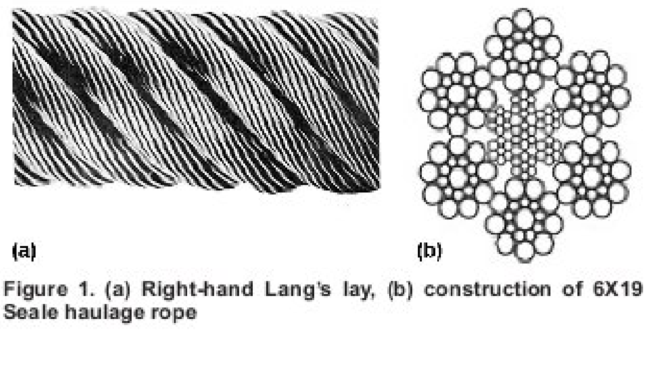
A wirerope defectograph using the DC magnetic method (also known as the permanent magnetic method)[3-4] is suitable generally for magnetisation of the rope with permanent magnets and detection of the changes of magnetic field around the rope and total magnetic flux. Various types of sensors can be adapted to the instrument depending on the design of the magnetic concentrators and type, number and location of sensing devices. Inductive coils and/or Hall generators are very popular as sensing devices. Sensors are divided into two types: (1) Local Fault (LF) sensors and (2) Loss of Metallic cross-sectional Area (LMA) sensors.

A broken wire or corrosion pit creates radial magnetic flux leakage and the LF sensor detects it as the rope passes through the sensor. This signal provides information about the presence of a local fault and also information about its magnitude to the extent required.

The LMA sensor measures total axial magnetic flux in the rope as an absolute magnitude or variations in a steady magnitude of the magnetic field. This signal is proportional to the volume of steel or the change in steel cross-sectional area. It provides information about loss of steel due to missing wire, continuous corrosion or abrasion.

Observations

Non-destructive investigation of a Voest-Alpine Austria Draht-make haulage rope of 34 mm nominal diameter with polypropylene



(a) (b)

Figure 1. (a) Right-hand Lang's lay, (b) construction of 6X19 Seale haulage rope

core, in a cable car in India, was carried out for the first time after five years of installation. The rope was stranded 6X19 Seale in construction [PP+6(1+9+9)] (Figure 1(b)). The material and finish of galvanised wires were according to ONORM M9503 and the lay of wires was right-hand Lang's lay. The approximate length of the rope was 800 m. The rope was single (monocable) and continuous in nature but the ropeway arrangement was zigback with two cabins – one going towards the Upper Terminal Point (UTP) and the other moving down towards the Lower Terminal Point (LTP). The haulage rope was studied *in-situ* by means of a magnetic defectograph[5].

The minimum and maximum diameters observed during study were 33.0 mm and 33.9 mm respectively against nominal diameter of 34 mm. The laylength (Figure 2) observed was 238 mm (7d) and the spliced length (Figure 3) was 41.5 m (1220.5d) where d is the nominal diameter (in mm) of the rope. The rope speed during investigation was approx. 1.0 m/sec. This non-destructive investigation on the haulage rope revealed six localised flaws at a distance of 178 m, 547 m, 612 m, 668 m, 669 m and 731 m respectively from the last tucking point of the conventional splicing splice while the rope was moving in its usual direction.

The wirerope defectograph was calibrated by 80 sq mm and 20 sq mm rods. The steel cross-sectional area for stranded rope has been assumed about 55% of the full cross-sectional area. The relative loss in cross-sectional area (due to distributed flaws) with respect to a healthy portion of the rope was about 4.45% (max).

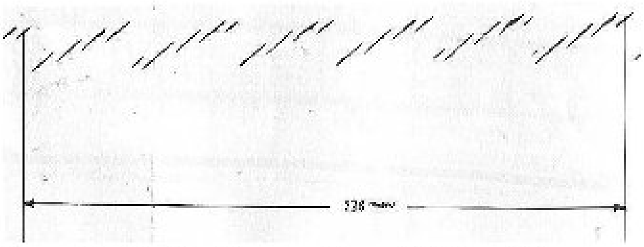


Figure 2. Laylength of the rope observed during study

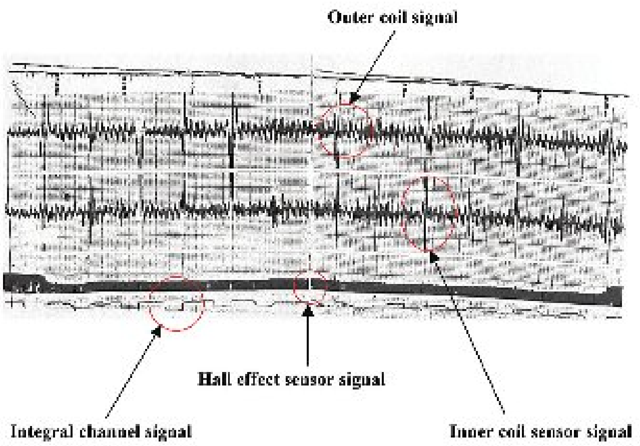


Figure 3. Spliced length of the rope

Results and discussions

This investigation was carried out after five years; not within one year after installation. Usually, the rope is examined after normal stretch in the installation to find the manufacturing defects, if any. The maximum diameter reduction was 2.94%. The spliced length was 1220.5 times nominal rope diameter. The laylength was seven times the diameter. This value lies between 6d to 8d where d is the nominal diameter[6]. This range is generally accepted. Maximum relative loss in cross-sectional area was 4.45%. Continuation of the rope was recommended.

Conclusions

The 6X19 Seale construction, with its large outer wires, provides great ruggedness and resistance to abrasion and crushing. Periodic *in-situ* measurement of faults in ropes would help to find out the effects of various parameters on rope life. It also emphasises the priorities of wire break discard criteria supported theoretically and experimentally. The present non-destructive study on haulage rope does not include the aspect of fatigue, which may develop in rope in the course of time. With the result and recommendations of the study, the concerned management will be able to take a decision either to replace the ropes in use from installation or to extend the life of existing ropes.

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References

1. J R Wait, 'Review of electromagnetic methods in nondestructive testing of wire ropes', Proceedings of the IEEE, Vol 67, Issue 6, pp 892-903, June 1979.
2. Wire rope and accessories, www.denverwirerope.com/html/wire_rope_and accessories/wirerope_and_accessories.htm
3. K Zawada, 'Magnetic NDT of steel wire ropes', NDT.net, Vol 4, No 8, August 1999.
4. D Basak, 'Non-destructive evaluation of drive rope: a case study', Non-Destructive Testing & Evaluation, Taylor & Francis, UK, Vol 20, No 4, pp 221-229, December 2005.
5. CIMFR (erstwhile CMRI), Project reports on non-destructive investigation on steel wire ropes.
6. D Basak, 'Comparison of condition of a haulage rope with non-destructive evaluation standards: a case study', Journal of Non-Destructive Testing & Evaluation, Vol 4, Issue 2, pp 43-46, Sept 2005.