Measurement of the Length of Lay in Stranded Ropes

G. Oplatka and R. Schwitter

1. The Background

One condition for the correct functioning of a wire rope is that its length of lay lies within the tolerances specified by the manufacturer. In a rope with a length of lay that is outside these tolerances, the load distribution between wire layers may be incorrect (Fig. 1) [1]. Early wire breaks may occur on dynamic loading of such ropes for two main reasons:

- in slackened layers on the outside of the rope wire breaks are caused by excessive deformation
- inside layers may be overstressed and longitudinal tension in the wires may become too high.

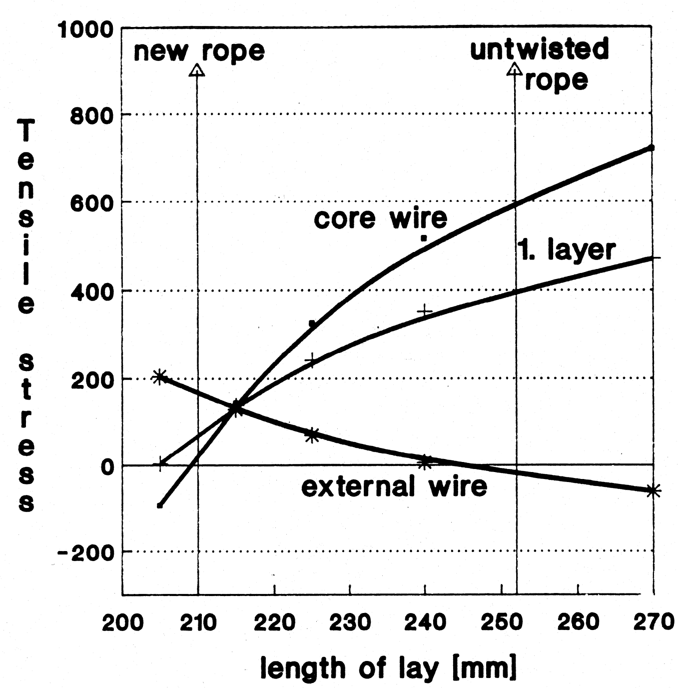

Fig. 1 Tensile Stress in an individual wire of an untwisted stranded wire rope [1].

Prof.Dr.Dr.h.c. Gábor Oplatka, Dipl.-Ing.ETH Remo Schwitter, Institute of Lightweight Structures and Ropeways of the Swiss Federal Institute of Technology, ETH-Zentrum LEO, CH 8092 Zürich Tel. ++41-1-633 25 10, Fax ++41-1-633 11 10,
e-mail: oplatka@ils.mavt.ethz.ch

There are three additional problems associated with incorrect length of lay:

- under compressive stress wires may protrude from the bundle
- in ropes running over rollers incorrect length of lay may give rise to vibrations [4],[5]
- the magnetoinductive control of such ropes is difficult because in slackened portions of the rope the ends of broken wires are not pulled apart.

Therefore the length of lay is measured on a number of occasions during the lifetime of the rope. Examples of such occasions are the end of the manufacturing process, the acceptance of the rope by the buyer, after the installation, during periodical checks and after possible damage.

2. State of the Art

Today length of lay is normally measured on a stationary rope. To perform the measurement, a strand is selected on the rope surface and is marked. The next appearance of the strand on the same side of the rope surface and parallel to the axis of the rope is also marked. Now the distance betwen the marks is measured (Fig. 2). To increase accuracy, measurements are taken over several lengths of lay. This method of measurement has the disadvantages that it is unreliable, takes a lot of time and must be repeated a large number of times to find extreme values of the length of lay.

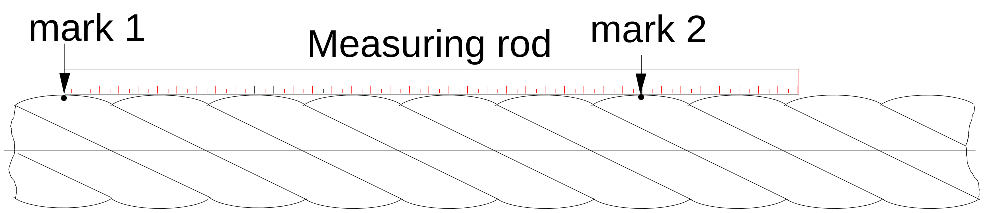

Fig. 2

There is a continuous method of measurement [2] that is more satisfactory. This uses a friction wheel to record the length of rope. At the same time a counter counts the number of strands along the measured length (Fig. 3). The length of lay is given by dividing the two quantities (length of rope , number of strands). This method has its limitations too. Measurements are made along a longer piece of rope to increase measuring accuracy. This means that no specific length of lay but only the average can be measured. Another problem is that any axial rotation of the rope during the measurement will falsify the results.

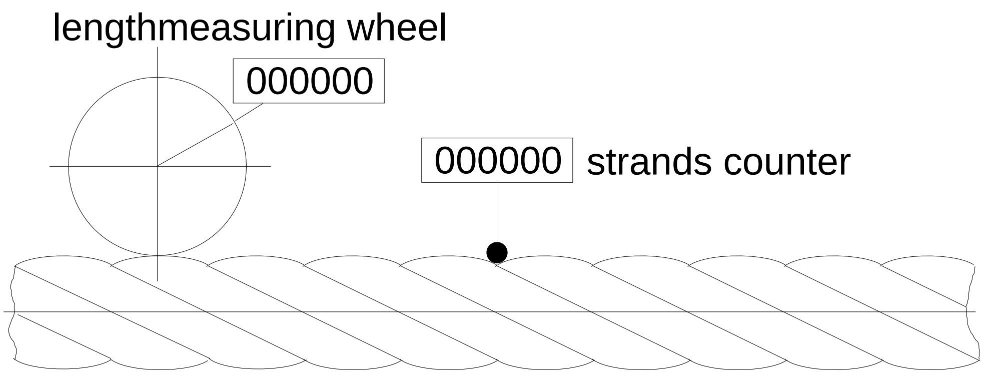

Fig. 3

3. Continuous Measurement on a Travelling Rope – Specifications

An instrument for the continuous measurement of the length of lay on a travelling rope was developed during course–work leading to a degree. Part of the specifications was that the instrument should be suitable for use in the field and that it should have a measurement accuracy of some 2%. Further aims were that measurement results should not be affected by soiling of the rope, by wire breaks or through axial rotation of the rope.

4. Principle of the Measuring instrument

Having examined a number of ideas for the design of the instrument we found the one presented here. It fulfils all requirements and is amazingly simple.

Two sensors were fixed, each at an axial distance of a few millimeters from the rope. The sensors were lined up along a line running parallel to the rope axis. The distance between the sensors was set at the actual perceived length of lay. Each sensor measures the distance to the rope surface passing immediately under it. A diagram of the results is a pair of near-sinusoidal curves (Fig. 4) as the rope travels under the sensors.

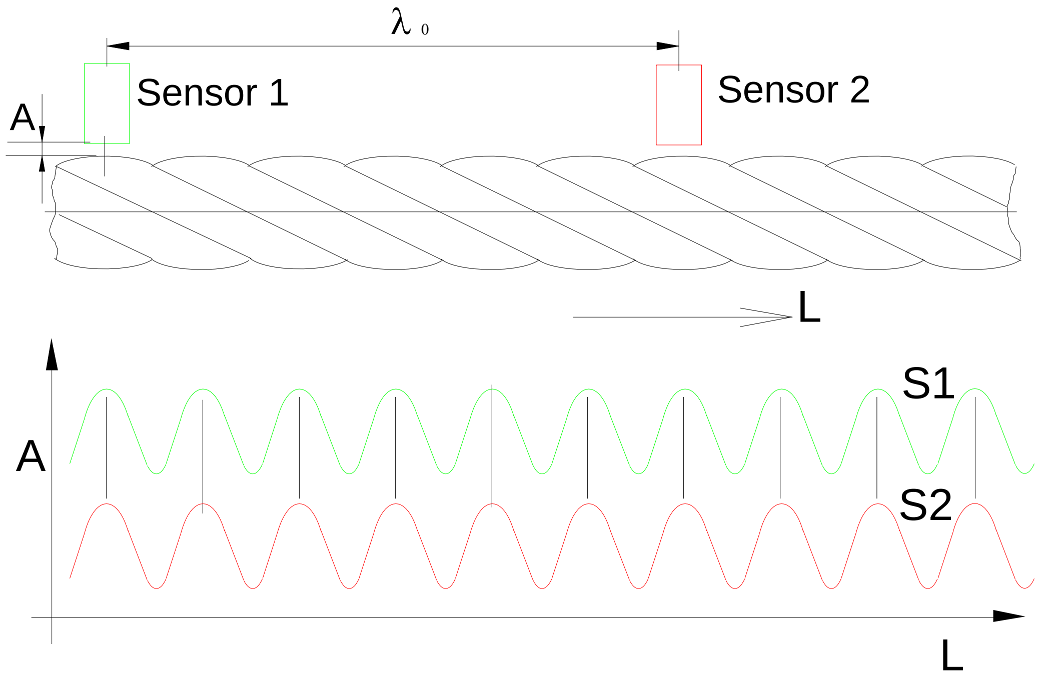

Fig. 4

The phase relation of the two signals stays the same as long as the length of lay of the rope stays constant. This is independent of any axial rotation of the rope. As the length of lay changes the phase difference between the two signals changes proportionally (Fig. 5).

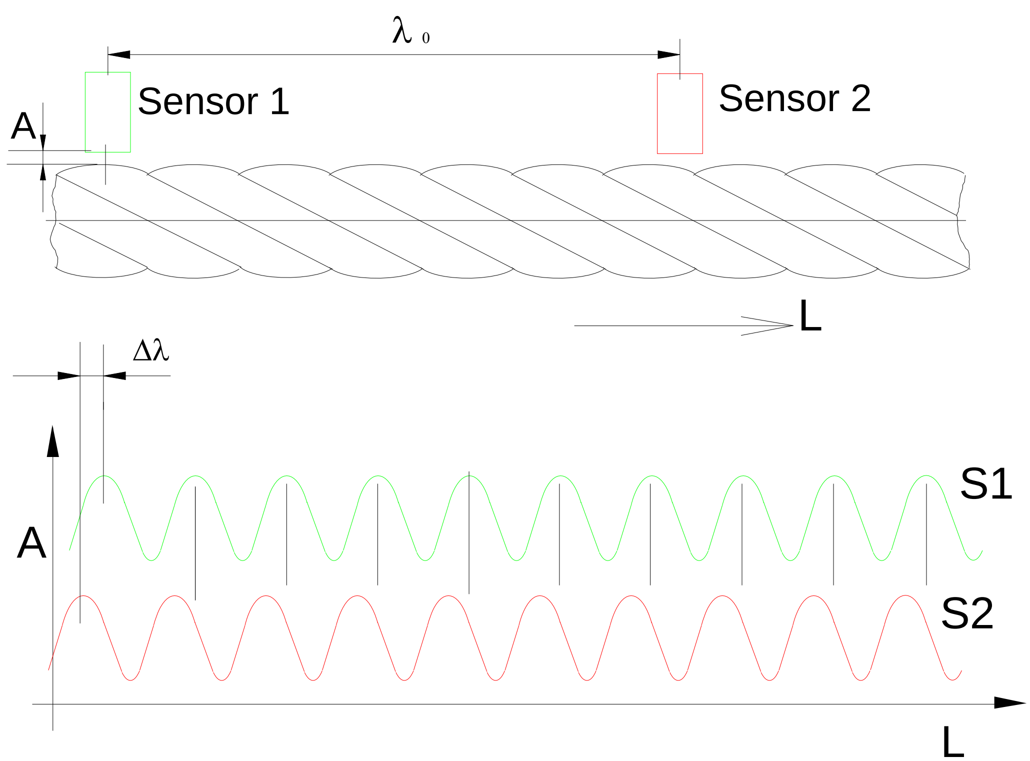

Fig. 5

5. Measurement and discussion

The sensor output signals were digitalized and fed to a computer. The output of one of the sensors was used as a reference signal: knowing the pitch of the strands the signal period effectively gives the scale of length along the rope. Each length of lay of the rope passing under the sensors is calculated from the phase difference between the maxima of the signals from the two sensors, the time infomation being converted to length according to the scale of length derived from the reference signal.

To allow locating the part of the rope being examined a friction wheel measures the distance along the rope (Fig. 6). As the sensors chosen are inductive, soiling of the rope such as a full strand-gap does not affect the results of the measurement as long as the soiling is not metallic. If the rope is distorted in the form of a corkscrew, this does not affect the measurements either, as the results of the distortion (higher or lower lying strands) are measured equally by the two sensors.

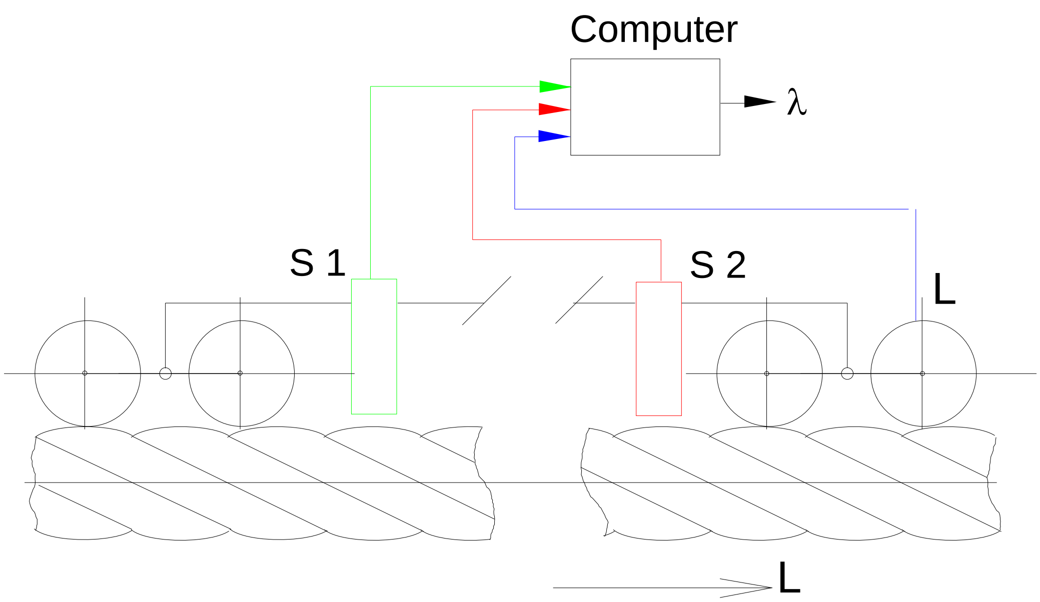

Fig. 6

The required accuracy of 2% can be achieved with the sensors chosen and the following conditions:

- sampling frequency: 500 Hz
- rope speed does not vary more than 20% while a length of lay passes under the sensors
- the strand frequency does not exceed 28 Hz.

6. Measurement results

To illustrate the efficacy of the measuring technique described we show two applications on actual installations (Fig.7 and Fig.8).

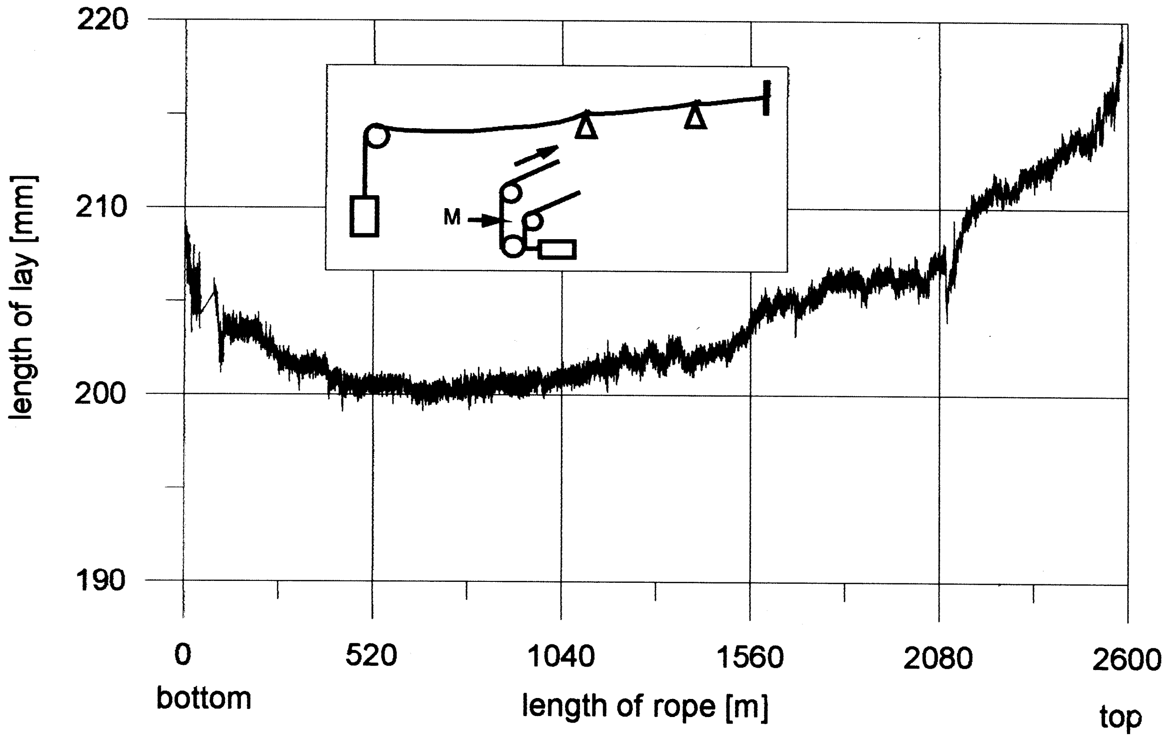

Fig. 7 Variation of the length of lay of the hauling rope on a reversible tramway while traveling from the bottom to the top station. Measurements were taken at point M in the bottom station.

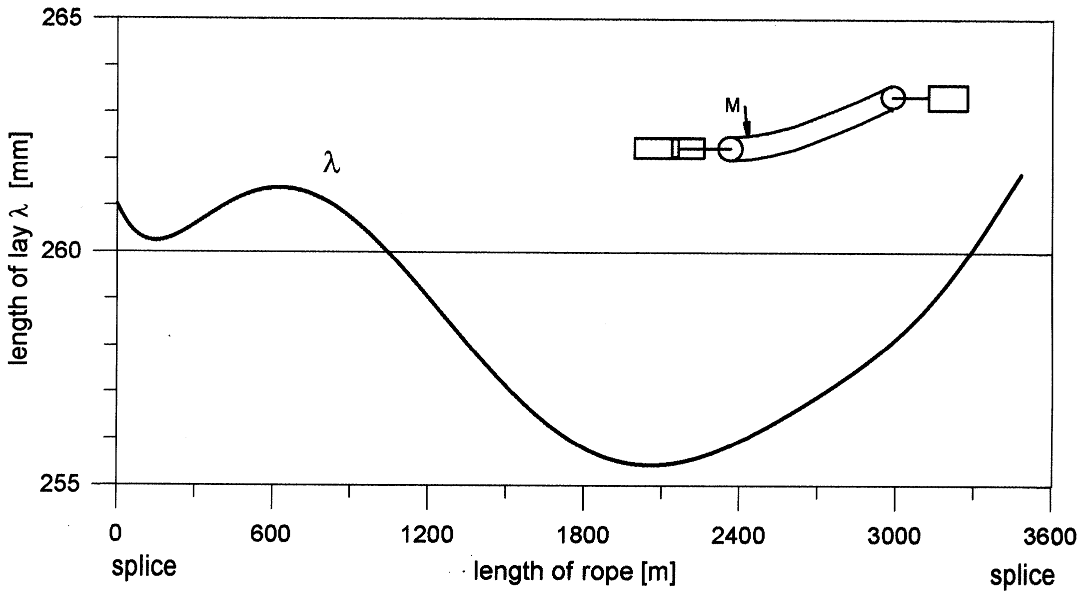

Fig. 8 Variation of the length of lay in an empty rope of a chairlift. To increase the length of lay the rope was untwisted at both ends before splicing. In spite of running the rope around for a longer time its length of lay did not become uniform along the rope. Shown is a smooth curve (orthogonal polygon with degree 9).

7. Bibliography

[1] Haller, A., Experience with untwisted ropes. OIPEEC Round Table Conference. Zürich, 1989.

[2] Briem, U., Verbesserung der Ablegereifeerkennung laufender Drahtseile durch Kombination von Ablegekriterien. Diss. Universität Stuttgart 1996.

[3] Schwitter, R., Kontinuierliche Messung der Schlaglänge am laufenden Litzenseil. Diplomarbeit ETH Zürich 1996.

[4] Oplatka, G., Zum ruhigen Lauf von Litzenseilen über Rollenbatterien. ISR 8/93.

[5] Maul, G., Oplatka, G., Rope vibration – particularly in monocable systems. OITAF 8th International Congress, San Francisco, 1999.