Force Measurement in Slacklines – Application Report

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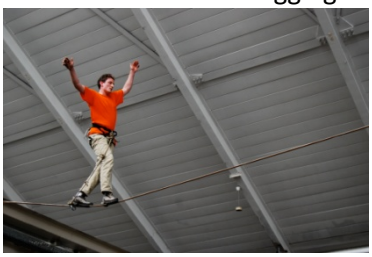
1. Slacklining:

Based on the climbing-scene, Slacklining is a trend sport, which experienced an incredible upswing in the past two years. Although the roots of this sport are in the legendary (climbing-) „Camp 4“ in Yosemity-Valley (USA) in the seventies, it is just now becoming popular.

For Slacklining, a flat, elastic synthetic fiber band (25-35 mm) is clamped between two fixed points (e.g. two trees) by a chain-block or a ratchet. The sportsman attempts to walk on this band and tries to accomplish different stunts (tricks). It seems that Slacklining resembles the (wire-) rope-dance, however, it is different through the varied materials and also extensive in the requirements. Slacklines can be clamped in many different ways. Currently, the length varies between 5 and almost 200 m. For shorter Slacklines, the tension varies from sagging to strongly clamped. “Highlining“ is considered the supreme discipline. Here, a Slackline is arranged above the jump height, e.g. between two rock crests. Each of these different Slacklines bear their own dangers and risks.



2. Setting of a Task:

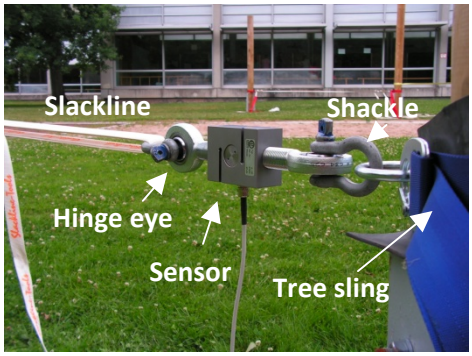
The occurring forces in a Slackline get larger very fast. The physical backgrounds are known only by very few Slackliners and this is regularly resulting in misjudgments and from that dangerous material failures.

The installation of a force sensor in Slacklines in courses and in workshops is supposed to elucidate the size of the forces and the resulting danger potential.

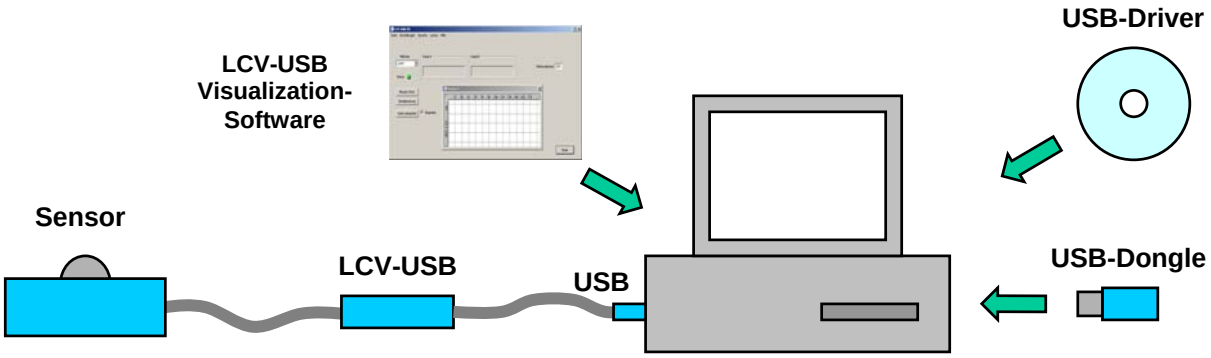
Even advanced Slackliners often misjudge the occurring forces, so that the systems become unnecessarily over-dimensioned and thus not transportable. Due to the length, very long Slacklines, so-called “Longlines” must be operated with very high initial tension (~10 kN), so that the sportsman does not touch the ground in the middle. Despite highly performed gripping mechanisms (chain block/15:1 tackle), the force sensor helps to keep the forces under control and thus stay below the load limit of the material. At “Highlines”, the initial tension is not so large but the sportsman safeguards directly at the band which will also cause accordingly high forces when falling down. So

far, the sportsmen met the danger here by very over-dimensioned systems with multiple redundancy. However, only very little is known about the actual size of the occurring forces. In order to optimize the safety of the Slackline set-up, these loads must be examined closer by the help of a force sensor.

3. Measurement Set-Up:



The force sensor K-25 (measuring range 20 kN) of Lorenz Messtechnik was equipped with a M24x2 hinge eye on both sides and was then directly mounted in the Slackline through shackles. Via the USB-Amplifier LCV-USB, the sensor was directly connected to the USB-Port of a laptop. According application, the measured data was recorded with the supplied software LCV-USB-VS and represented in a force-time-diagram, or the laptop was used as an analog display for the force sensor through the software Lab-View. In order to impart the occurring force in the line to the Slackliner, by means of Lab-View the force value was coupled to the frequency of a sine wave generator which allows a relative estimate of force through the active sportsman.



4. Force Measurement in Ongoing Course Action::

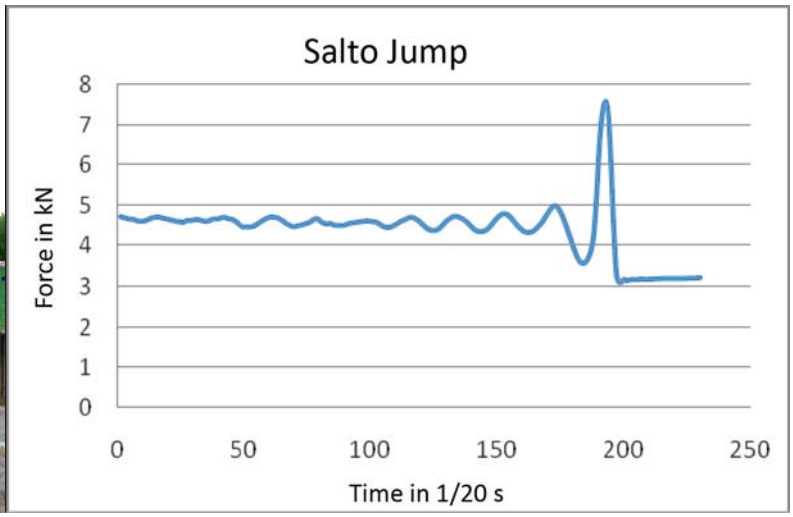
In the courses, the force sensor was installed in one of the assembled lines. By this, the course participants were able to watch the acting forces at various actions on the line during the entire exercise lesson. Of special interest here was the installation of the force sensor in so-called Jumplines, at which surprisingly high forces of approx. 9 kN were reached very fast.

This enabled an easy insight into physics of the Slackline for the course participants. They were very impressed by the actual size of the forces.

5. Force-Curves at Various Tricks

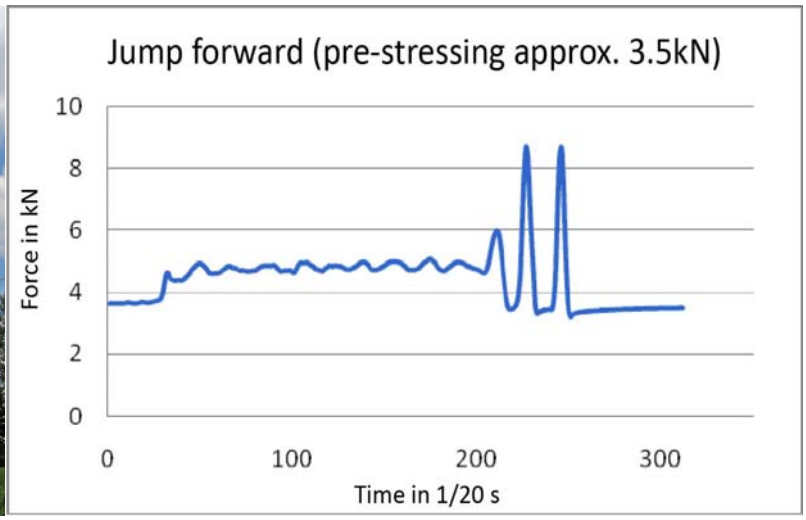
Like before, the force sensor was installed in the line (8 m), directly and the force-curve was recorded during two different tricks.

Salto Jump



By the weight of the Slackliners, the force at the beginning is approx. 5 kN. When the sportsman starts swinging, it can be seen very well in the force-diagram. After the clearly recognizable jump on which a peak force of approx. 8 kN acts in the meanwhile, the force decreases to the initial tension value of 3 kN.

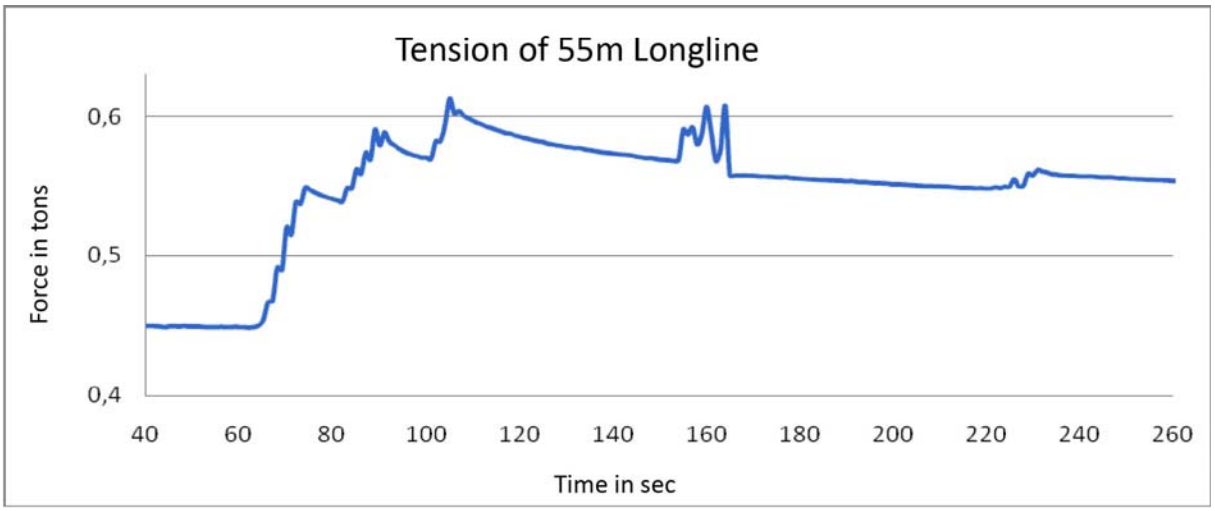
Jump Forward



The slowly swing-start is easily recognizable. Two obvious force peaks of approx. 8,6 kN record the jump and the landfall.

6. Force Control at Longline Set-Up

Now, a 55 m Longline was clamped through a 45:1 tackle. During a fragment of the clamping procedure, the force was recorded through a directly installed force sensor.



Here the single force travels of the tackle are shown well. It is especially striking that in the phases in which the system rests, the force slowly exponentially falls back into the system, which results from the textile material characteristics of the band.

7. Result

The measurements that were carried out by the force sensor of Lorenz Messtechnik as well as the related measurement periphery allow interesting conclusions. For example it showed that even in short and not very tensed Slacklines (below 5 kN initial tension) at jumps and similar tricks very high forces of approx. 9 kN can act. Some manufacturers offer Slackline-Sets with ratchets which have a tension force of only 7,5 kN. These systems can reach their limits during the daily Slackline use. The modern measurement technique of Lorenz Messtechnik enables to upgrade the dimensioning of the used Slackline material.

The measurements also show that a Slackline does not behave like a Hookian spring. The effects of the textile material characteristics, non-linearity and hysteresis clearly dominate the dynamic behavior of the synthetic fiber band. This new knowledge can enter into the optimization of clamping processes and band materials.