

VIBRES System Technology for Measuring Ground Anchor Tension Using Vibrations 2023 PIARC Prize - Best Innovation Prize Winner Système VIBRES

Technologie de mesure par vibrations de la tension
des ancrages au sol Lauréat du
« Prix PIARC 2023 – Meilleure innovation »



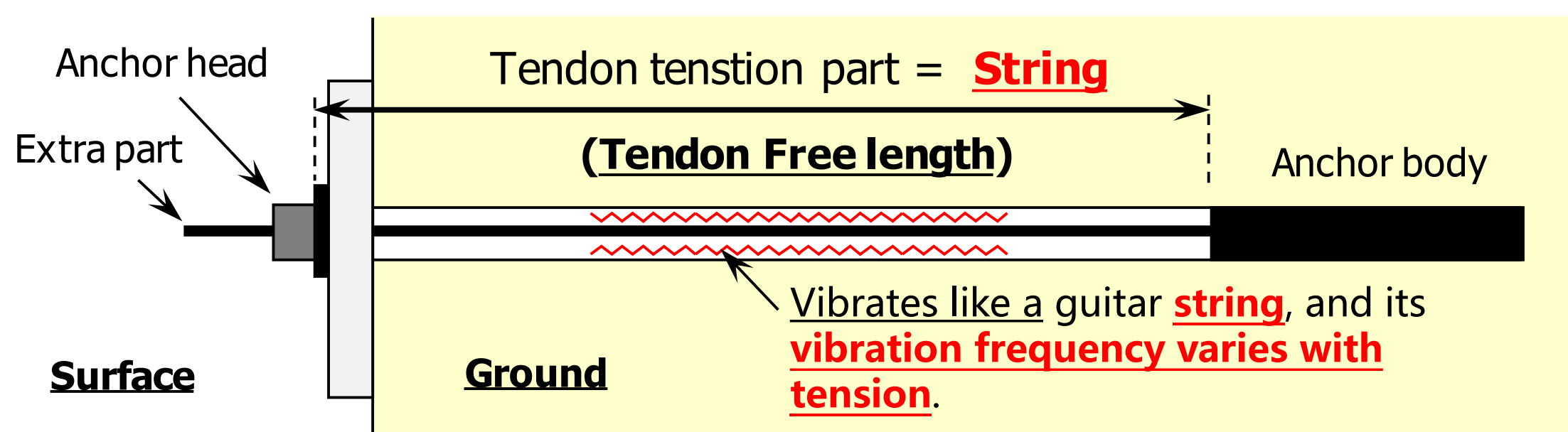
- A ground anchor (hereafter referred to simply as "anchor") is a tendon with one end anchored in stable ground and the opposite (free) end tensioned so as to stabilize a structure such as a slope. Anchors, therefore, need to be inspected.
- During a tension inspection, it is common to conduct a lift-off test using a center-hole jack. However, this test may require heavy equipment and, in some cases, temporary scaffolding.
- The VIBRES system is a new technology to measure anchor tension efficiently using vibrations.

Principle of the VIBRES system

An anchor consists of an anchor body, a tendon, and an anchor head. Since the tendon of an anchor is a relatively slim member whose thickness is significantly smaller than its length, the free length of the tendon may be regarded as a 'string' fixed by the anchorage zone and the anchor head. The vibration frequency (f) of the string is determined by the linear density (μ) of the string, string length (L), and tension (T), and their relationship can be expressed as shown below. The VIBRES system measures the vibration frequency of the tendon free length.

$$T = 4 \times L^2 \times f^2 \times \mu$$

- T : Tension (N)
- L : Tension Free length (m)
- f : Resonance frequency (Hz)
- μ : Line density (kg/m)



Measuring method of the VIBRES system

Since the free length of the anchor tendon is underground, its vibration frequency cannot be measured directly. The VIBRES system uses a small vibrator installed on the extra-length portion and applies sweep vibrations whose frequency increases over time. When the frequency of the vibrations and the frequency of the free length coincide, resonance occurs. The frequency of this resonance is measured with the accelerometer installed on the extra-length portion to determine the tension of the anchor. One measuring session takes 60 to 120 seconds.

In addition to the small vibrator and the accelerometer, the measurement uses a compact measuring unit and an analysis program installed in a computer. No large equipment is required as in conventional lift-off testing.

• VIBRES installation • Acceleration waveform and received waveform • Measuring unit

• Example of analysis (on the computer screen)

Accuracy of VIBRES system

Comparison of tension measurement results obtained from the VIBRES system and a conventional lift-off test showed that the tension measurements obtained from the VIBRES system were largely within $\pm 10\%$ of the lift-off test results. The VIBRES system is a breakthrough and unique technology that enables efficient inspection and safety enhancement by using vibrations to measure anchor tension.

* The VIBRES system was developed jointly by Central Nippon Highway Engineering Nagoya Co., Ltd., Oyo Corporation, and Gifu University.

