Convergence Measuring Instruments

Levelling measurements of the tunnel roof or other points of the tunnel reveal and convergence measurements of the excavation have developed into the most frequently applied methods of measurement in tunnelling.

To install a convergence measuring section, convergence bolts are positioned as close as possible behind the round in the tunnel reveal (set in concrete or welded on arches). At the tunnel end of the convergence bolts is a thread with a stop for attaching the measuring device (a steel measuring tape or invar wire). A spring pretensions the measuring tape with the convergence gauge, which is also fastened to a convergence bolt on the other side. The change in length between the reference points is read off a mechanical dial gauge on the convergence gauge.

To minimise disruption of the construction work, geodetic measurements have become increasingly popular of late as a means of monitoring convergence. Instead of using convergence bolts, a measuring bolt with luminous diode or reflecting signal is set in concrete and its displacement measured with a theodolite. Measuring accuracies of $\pm$ 1 mm are possible and satisfy the stability inspection standards for tunnelling projects. The advantage of this method compared with taking relative measurements between two moving points using a convergence gauge is that it measures the absolute displacements in an excavation. When convergence measurements are taken with a convergence gauge, this is only possible in combination with at least one geodetic measurement.

To carry out continuous convergence measurements we have developed an electro-optical system. In conjunction with a laser it allows you to take convergence measurements automatically at any intervals. This method of convergence measurement is ideal for long-term monitoring of existing, older tunnels.

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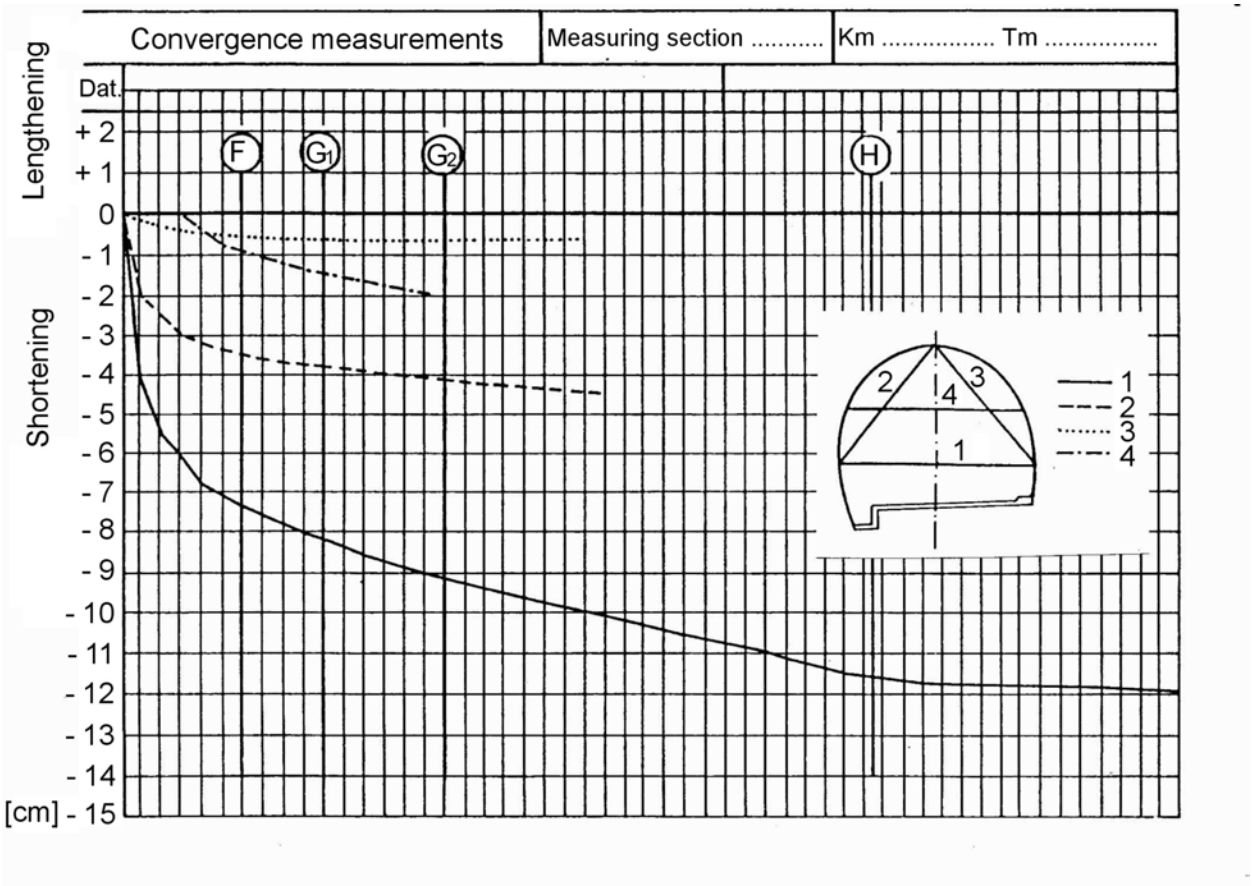

Fig. 1 Example of a convergence measurement. F: Subsequent anchorage of abutments; G1: Foot anchors; G2: Doubling of foot anchors; H: Bottom end

Levelling and convergence measurements are the most basic measurements in tunnelling. They are normally taken in standard or main measuring sections. Fig. 1 shows a typical measurement result in schematic form.

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