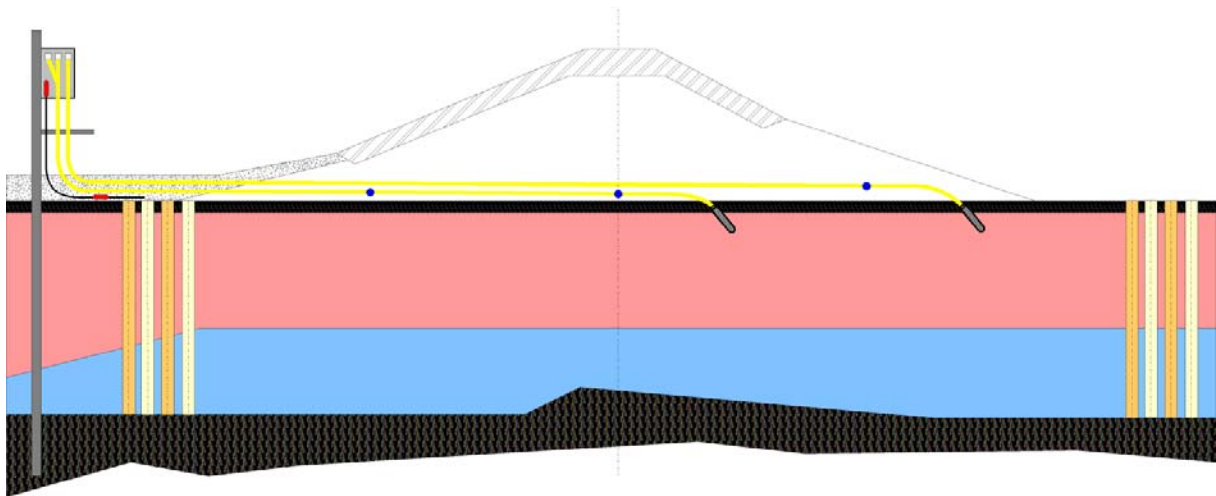


Combined Hydrostatic Settlement Measuring System

Pointwise Settlement Monitoring and Horizontal Profiles Measurement



System Description

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1. Introduction

Classical settlement gauges disturb the daily construction activities in a great deal. If they are not costly protected, they will be damaged or destroyed after some shortest time. Due to the damage through a vehicle or a structure-movement, a slight tangential deviation leads to a relevant failure in the calculated settlements from the geometrically correct levelling. A further disadvantage is that the gauges give an existing information of the settlement only at particular points, which in fact the settlement can be locally very different. These inhomogeneous settlements represent however a relevant loss for the structure.



In spite of everything, the method is commonly used, because the reading can be carried out economically through our own personnel.

2. Measuring Principle

In a further development of the hydrostatic measurement method of horizontal profiles (*Lhotzky System*), the engineering consultant "Lhotzky + Partner" is currently offering a new method. The new method enables a pointwise monitoring of particular points of a measuring cross-section through the personnel of the customer, and on the other side the engineering consultant "Lhotzky + Partner" offers an option of the on-site high resolution hydrostatic measurement of horizontal profiles for the overall cross-sections. In contrast to the classical settlement gauge method, the reference point in the new system lies outside the construction activities, and the real measuring points are arranged by the soil cover protected on the foundation of the measuring cross-section.

The functional principle is to be exemplified at a measuring cross-section in a dam embankment, in which three classical settlement gauges are to be replaced by hydrostatic measuring profiles. The measuring positions should lie in 30 m, 55 m and 80 m.

In addition two special measuring system test-pipes (LDPE-Coated), type "Horizontal profiles measurement", with lengths of 60 m and 85 m are mislaid parallel to each other. Each system test-pipe comprised 4 internal tubes, which every couple of them can be used for the hydrostatic settlement measuring point or for the horizontal profiles measurement. In the example configuration, the first system test-pipe with lengths of 85 m uses the first internal tube couple for the settlement measuring point 80 m, and the second internal tube couple remains freely for an optional possible measurement of horizontal profiles of the overall measuring cross-section at any time. The other two measuring points at 30 m and 55 m will

be monitored in the second system test-pipe. Parallel to the configuration of the system test-pipe, two temperature gauges are installed in a protection pipe on the first meter, in order to survey the transition area of changing outside temperatures to constant temperatures at the embankment.

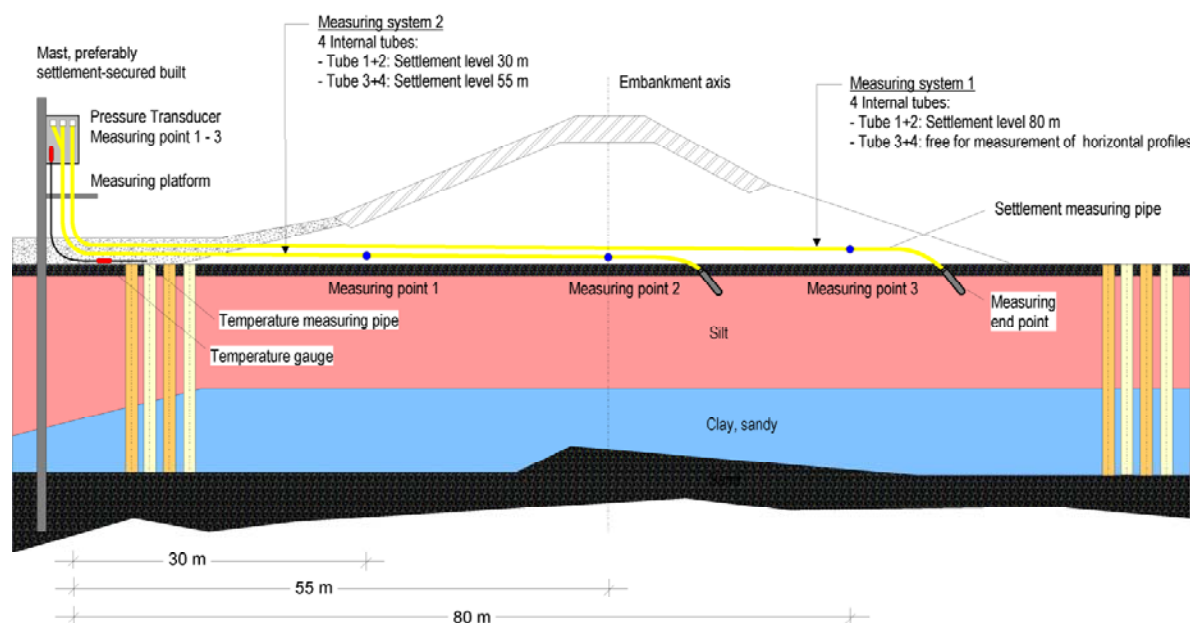


Fig. 1: Principle sketch of the hydrostatic settlement gauge with an option measurement of horizontal profiles

All measuring system components end in a terminal box, which is fixed to the settlement-secured built mast. If the mast cannot be built securely, then a monitoring adapted to the settlement behaviour of this reference elevation is necessary.

In the areas with less overcover, the measurement system test-pipes should be protected with a special protection pipe (PE-Pipe). Due to the less heating by solar radiation and the larger flexibility, a corrugated yellow drainage pipe (DN100) is used as a protection for the interstitial protected areas before and at the mast.

For the implementation of the hydrostatic settlement gauge, an internal tube is filled with the degassed water until the desired measuring position. The remain of the first internal tube is filled with air and connected with the second internal tube at the overwhelmed end point of the horizontal profiles, so that the reference pressure fits at the measuring point. In the box, both tubes are connected respectively to the pressure transducer, which one of the tube monitors the hydrostatic elevation of the supervised point and the other monitors the reference pressure. All three reference pressures will be monitored by a pressure transducer. The absolute elevations of the supervised points are calculated from the measured pressure elevations, temperatures as well as characteristics of the pressure transducer and the known

reference elevations of the mast. The measured values are then read out with a hand-terminal. Afterwards the stored data are read out on a computer, handled, and processed by means of a special software into tabular data and graphic.

3. Installation

The system test-pipes are delivered pre-assembled and they can be mislaid freely along the monitored profile (Fig. 2). The direct covering should be carried out with stone-free material.



Fig. 2: Simple laying of the horizontal profiles measurement

The connection of the system test-pipes at the fittings in the terminal box takes place at the reference measurement of the settlement measurement of horizontal profiles. The reference measurement of the horizontal profiles is necessary, so that the monitored measuring point can be started up accurately later. On the other side, the incurred settlement for the complete profile can be calculated based on the elevation acquired after the installation at any optional measurements of horizontal profiles.

4. Readout and Analysis of The Settlement Gauge

The readout of the hydrostatic settlement gauge succeeds with a PRODATA-Data Logger on conceivably simple form. Firstly both flooding secured connectors (Temperature gauges and pressure transducer) are connected with the device, and after the device is activated, the measured values can be shown on the display and simultaneously stored at the push of a button. Afterwards the stored data record can be assigned directly to the measuring cross-section via an add-on channel in the software.

After readout of the specific measuring cross-sections, the data logger is connected to the PC and the data are read out with the software *ProSP*. The acquired data are assigned automatically with the encoded channel to the specific measuring cross-sections, and converted in consideration of the temperature, the reference pressure as well as the reference elevation on the sea level. The results can be represented both tabular and graphic. For the advanced processing, an Export-Function (CSV-Format) is available in the software package like Microsoft EXCEL.

5. Optional Hydrostatic Measurement of Horizontal Profiles

The cyclic readout of the current elevations of the pointwise hydrostatic settlement gauge gives an economical option to the implementation of the hydrostatic measurement of horizontal profiles in the same test-intervals. With hydrostatic measurement of horizontal profiles, we obtain also the elevation- and settlement information of the overall section with a high frequency of measured values instead of just one particular elevation information.

The represented monitoring system is now offering the alternative to combine both methods according to requirements. On the analysis of the hydrostatic settlement gauge, we determine the noticeable problems that need a particular test, so the hydrostatic measurement of horizontal profiles can be executed in the still free internal tube couple. Therewith we obtain an elevation profile of the overall measurement connection with high local resolution (Normally 25 cm) as well as the difference representation (Settlement) to the reference measurement and to previous measurements of horizontal profiles.