Application possibilities of on-line rock pressure measurement with the tunnel construction

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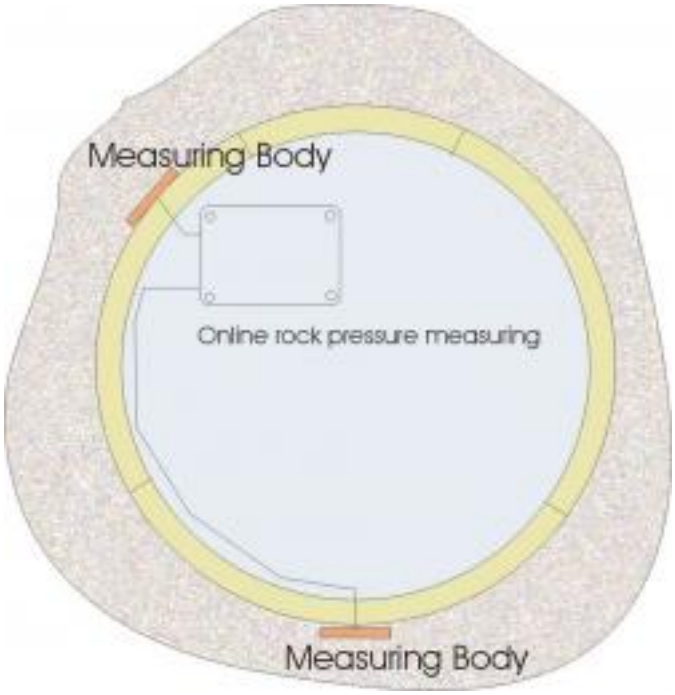

The instrumentation use of the akusto elastic effect makes qualitatively and quantitatively new safeguards methods possible with the building and with the enterprise of tunnel. When example of possible applications know tunnel-build with high overlays and/or large rock pressure features are called, with those already during the construction period, which can be measured force application of the working forces of the tunnel drilling machine into the mountains surrounding the tunnel.

1. Instrumentation bases of on-line rock pressure measurement

These new applications of the akusto elastic effect for the interests of the tunnel construction are seized by several relevant patent specifications:

Device for the determination of the mountain tension in a borehole - DE102005047659B4
Procedure and device for the early recognition of building damage - DE102006053965A1
Device and procedure for the load measurement of bridge bearings - DE102007014161A1
Procedure and device for the determination of the mountain tension - DE102008037127.0

The measured variable is in all applications the running time ultrasonic impulse in a homogeneous measuring body, for example made of metal. Favourable way is this measuring body a metal plate with a PVDF foil. The force application takes place up and concomitantly via this metal plate. The force application can be measured as a mechanical stress in the metal plate. As measured variable a running time is available, which is in reverse proportional to the mechanical stress in the plate. The akusto flexible effect describes the influence of tensile states on the propagation speeds of ultrasonic waves in the measuring body.

The out spreading speeds is described thereby in the following form, in which the material density, which elasticity and shear modulus (flexible constant of IITH order) as well as the flexible constant of IIITH order as material-specific

characteristic values and the three components of the orthogonalisis tensor, and/or which are received three main tensions as condition parameters of the measuring body. The propagation speed of the ultrasonic waves, which spread within the plate of the measuring body, is measured highly solubly with TDC circuits. With the use of metals these demands are fulfilled as far as possible. The adaptation of the ultrasonic transducers into or to metallic bodies is easily possible. The force application of the ground pressure over the exterior surfaces in the measuring bodies with the metal plate and the associated stress change is seized instrumentation as run time change. The measurement of the running time of the ultrasonic impulses, i.e. the determination of the speed of sound are possible for one or more ultrasonic sensors with. A sensor can work as transmitters and receivers and evaluate one or more reflections of the ultrasonic on the wall of the measuring section. Also two or several ultrasonic sensors, i.e. separate transmitters and receiver, can be used favourably. The akusto elastic effect can take place both via the measurement of the longitudinal (thrust) wave and via the measurement of the transversals (shearing) wave, or via evaluation of the change of both waves. It is valid the Reversibilität between expansion and upsetting.

The Hook law is valid only for the flexible range.

s (tension) = E (elastic module) * e (stretch)

The ultrasonic leaders made of metal fulfill the Hook law. The change of the speed of sound depends apart from the dependence on the influencing mechanical stress also on the temperature.

In practice the temperature equalizing between measuring bodies and surrounding building adjusts itself sufficiently fast. Larger variations in temperature are concrete in the stationary installation in tunnels, in the annular space between Tübbing and mountains not to expect.

With applications, where on a changing ambient temperature is to be counted, temperature measurements are conceivable for compensation and are easily in the measuring body capable of being implemented. By the flexible behavior of the measuring section between the ultrasonic sensors also the length of the measuring section is changed.

There is that for example the change of the speed of sound is so large by the effect of a mechanical stress (upsetting measure-strains) three times, like the influence of the pure length variation (by this tension or application of force on measure-strains develops) on the speed of sound, can via the measurement of the speed of sound, a sufficiently exact determination of the tension admits within the measuring body take place. If the time of flight of the ultrasonic waves takes place in the measuring bodies without multiple reflection and with sources of ultrasonic of high frequency, running times with small dispersion can be won.

For it PVDF foils are used favourably. The wide-band PVDF foils are particularly well suitable for time of flight. If loads are to be measured by only some MPa, the dissolution must be below 0.1 ns. For the collection of load besieging (or also redistributions of stress) in the order of magnitude 100 kPa and smaller the dissolution of the TDC circuits must be achieved by calculation of average values by means of many single measured values.

2. Application fields of on-line ground pressure measurement

Proof for the static group between Tübbing and mountains with the later compressed concrete (backfill) annular gap with long tunnel drivings. As example of possible applications of on-line ground pressure measurement with tunnel and/or shaft lining are mentioned pits and lugs with high overlays and/or large ground pressure features with alpine transit routes. Measurement very slowly itself developing mountain printings in rocks with high ductility and pore water printing. With the impact of such rocks very large and long lasting deformations can occur with the tunnel construction. If one tries to restrain these deformations by a rigid development, then develops a high, so-called genuine ground pressure in superposition with pore water printing, which can destroy the development.

The long, low-lying tunnels by the alps lend special meaning to the problem of the tunnel construction in printingful mountains. The measurement principle of on-line ground pressure measurement is independent of the water saturation of the environment. Long-term observation of the load admission of the tunnel tube with redistributions of stress in the mountains.

Conventional observations of the tunnel tube seize only deformations of the building. This geotechnical deformation or shift measurement can be determined only over the relative changes of position of individual often partially not visible points among themselves. In addition these geodetically determined points must be attached on. With on-line ground pressure measurement the stress measurement cannot only take place in the mountains, but directly the load creation can independently be based on each measuring point on the Tübbing, furnished for it.

Measurement of the forces between the Tübbings and mountains and the Tübbingen. With the tunneling with a Gripper TBM the propulsion press strength and the torque of the drilling head are cleared away over the spanning of the Gripper Pratzen into the rock. This brackets for example equipped with measuring bodies for load measurement is directly measurable the force application into the mountains in the brackets. Possible flexiblenesses in the load-absorbing mountains can be measured so

directly. The arrangement of measuring bodies between the Tübbingen makes the measurement for the demolition possible of the forces of a TBM with sign, necessary for the feed motion.

The feed press strength can be cleared away thereby over the timbering of Tübbings already finished. The orientation of the plates of the measuring bodies is turned thereby around 90°. If the admission of the transverse forces is to be supervised, the installation of the measuring bodies in the annular gap between the timbering of Tübbings and the excavated cross-section presents itself.

Thereby if Tübbings with connections for pressure sensors are used for the measurement of the injection pressure of the filling medium, the connecting cable for the measuring bodies can be laid by this opening. Likewise the force application can be supervised into the mountains with driving along curves of the TBM with on-line ground pressure measurement.

3. View for the application of on-line ground pressure measurement as a component of a tunnel monitoring

In the tunnel construction the monitoring the all possible effect and structural parameter forms the basis for the condition and safety analysis of the building during the building phase and the enterprise. The data seized with different geotechnical methods represent the basis for numeric and mechanical concept. The determining values of the parameters flowing into the concept can be won only from rock-mechanical values. On-line measuring procedures to force and load measurings, particularly stress measurements, do not have to be replaced in its force of expression and topicality. The most firmness and deformation from laboratory tests are linked so far insufficiently only with current deformation. With on-line ground pressure measurement the so far only modelful parameters can, as are measured the influence of the viscosities of the surrounding mountains on the stability of the development, with small expenditure and thereby the verification of all past models can improve substantially. From instrumentation view also the employment of RFI technology is conceivable. So measuring bodies with planar antennas or induction pick-up coils could be attached for the power supply of the ultrasonic units behind the Tübbings.Thus the installation is made possible for on-line rock pressure measurement without injury of the pressure water-close tunnel tube.

In January 2003 ibj technology as partner of the industry for the interests of the process measuring technique one based.

Owner of the engineer's office for innovative measuring technique is Mr. Dipl.-Ing. (TH), Dipl.-Ing.-Oek. Frank- Michael Jäger.

Our activity and thus our experiences in the process measuring technique for fastidious applications justify themselves on one over 15 years activity in the project management and development in research establishments of the chemistry, the natural gas industry and the mining industry.

The practical use of measurement principles and sensor technologies under most difficult operating conditions is supplemented by one over 12 years advisory activities to the employment and the use from process measuring technique to the benefit of the customers within all ranges of the economy.

As independent and reliable partners of the industry we offer comprehensive solutions in all questions of the process measuring technique.

Particularly with fastidious applications of the ultrasonic technology we can repair your problems with new solutions.

Many innovative solutions for measuring tasks in the most different industries were protected in a multiplicity by patents and utility models.

The satisfaction of the clients, expert quality as well as economically justifiable solutions.

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