In situ rock stress measurements from existing tunnels with the LVDT-cell

Advantages

• Robust, fast and reliable (Fig 1)
• Flexible, drilling is done with a compact drill rig
• Short boreholes – cost effective
• Verified quality in drill and blast tunnels
• Applicable for high stress conditions
• No gluing or hardening times
• Full service with one order

Description

• Five measurements around existing excavation profile yields full 3D in situ stress tensor (Fig 2)
• Basic layout in tunnel is to do two holes on opposite walls and three in the roof (Fig 2). In shaft or TBM-tunnel holes should cover half of the profile
• Measurement depth is 0.5 - 0.75 m from the tunnel wall in order to avoid the excavation damaged zone (Fig 3)
• Preferably the length of the measurement section is less than one tunnel diameter
• Method is applicable in good quality rock where at the minimum a 400 mm long pilot hole can be drilled in unfractured rock

• In the case of a drill and blast tunnel an uncovered surface and careful blasting is highly recommended
• Normally the overcoring technique is used but in high stress conditions core damage can be avoided by sidecoring
• Elastic parameters of rock are defined on-site by biaxial testing of pilot cores
• For the inverse solution a 3D surface model of the tunnel and measurement holes is built based on 3D photogrammetry (Fig 4)
• The full stress tensor, six unknowns, is solved based on 20 independent measurements hence increasing the confidence (Fig 5)
• The solution is based on tunnel scale numerical inversion representing a large rock volume (>1000 m³)
• Regular field work time for one five measurement hole section is one week
• Quality control is performed for field work
• Professional quality reporting
• Over twenty measurements in Finland and Sweden performed between 2009 – June 2013
Technical data

- The minimum diameter for a measurement profile is 1.5 m
- The pilot hole diameter is 126 mm and 200 mm for overcoring or sidecoring
- Continuous logging of pilot hole convergences with eight LVDT-sensors (Fig 1)
- Normal logging interval is one second
- Measurement resolution and cell stability is better than one micrometer enabling high quality data
- Continuous logging of temperatures for rock, the probe and flushing water
- Continuous logging of drilling advance
- Requires AC 400 V / 16 A, water line (hose), four survey points (x,y,z) and scaffold to get access to the tunnel roof

Figure 1. LVDT-cell version II for a 126 mm pilot hole.

Figure 2. The basic layout for five overcoring measurement holes around a tunnel profile.

Figure 3. The LVDT-probe installed in a pilot hole and ready for overcoring.

Figure 4. A 3D-photogrammetric model of the measurement section.

Figure 5. The interpreted in situ stress based on six different solutions (left) and the correlation between measured and best fit solution convergences (right).