SOME INFORMATION ON INVESTIGATIONS FOR THE PLANNING AND DESIGN OF ROCK EXCAVATIONS

Most types of investigations applied for underground excavations (based on: Palmström and Stille: Rock Engineering (2010))

When and where the investigation is performed | Types of Investigations
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Observations in outcrops, cuttings, test adits, shafts, or in existing tunnels | – Geological mapping
– Engineering geological mapping
– Joint survey
– Core drilling and logging of drill cores
– Test adit

Measurements and tests in situ | – Seismic reflection (acoustic) measurements
– Bathymetric measurements
– Seismic refraction measurements
– Cross hole tomography measurements
– Resistivity measurements
– Georadar, electromagnetic measurements
– Gravity measurements

Labaratory tests on samples | – Mineral composition and texture
– Uniaxial compressive strength
– Tensile strength and point load strength
– Shear strength
– Elastic constants
– Density, porosity, anisotropy
– Durability
– Slaking and swelling

Observations and tests in excavation | – In situ stress measurements
– Hydraulic fracturing tests
– Permeability tests or water loss tests
– Geo-observations and mapping in excavation
– Probe drilling ahead of tunnel working face
– Geophysical measurements ahead of face
– Deformation measurements

In addition there will be investigations for maintenance during the operation of the excavation

*) The relevance of some geophysical methods

<table>
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<tr>
<th>METHOD</th>
<th>MAIN INFORMATION</th>
<th>MAIN LIMITATIONS</th>
<th>APPLICATION</th>
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</table>
| Seismic refraction | - Thickness of soil layers  
- Location of ground water table  
- Location of rock surface  
- Approx. quality of rockmass | - “Blind zones” (if velocity does not increase with depth)  
- Side reflection | Extensively used on land and sea |
| Seismic reflection | - Locations of different layers (soil, rock, sea bottom, etc.)  
- Soil/rock structure | - “Blind zones”  
- Side reflection  
- Interpretation for great depths | Limited use (mainly used for sub-sea tunnels) |
| Crosshole tomography | - Rock mass quality  
- Karst caverns etc. | - Interpretation uncertainty | Increasingly used |
| Electric resistivity | - Location of ground water table/rock surface  
- Approx. character of weakness zones | - Interpretation  
- Stray current/buried metal | General use |
| Electromagnetic (radar) | - Location of ground water table/soil structure  
- Openings | - Restricted mainly to soft ground | Limited use |
| Magnetic | - Structural geology | - Interpretation | Minimal use |
| Gravitational | - Structural geology | - Interpretation | Minimal use |
### Schematic overview of usefulness of main field investigation methods

<table>
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<tr>
<th>Method</th>
<th>Purpose</th>
<th>Geological setting and rock distribution</th>
<th>Rockmass qualities and distribution</th>
<th>Depth to rock surface</th>
<th>Rock or rockmass properties</th>
<th>Weakness zones</th>
<th>Rock stresses</th>
<th>Ground water conditions</th>
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X: Well suited method; (x): Method may be useful; -: Method may be give some information

*) other types of boreholes, test adits, or shafts in rock may also be made for similar purposes

**) includes: probe drillings, geophysical measurements including seismic tomography