Geophysical services in Ramboll

Geophysical measurements comprises different non-destructive methods to measure various parameters of the soil or terrain. The measurements can be carried out on the ground, in the air, on the water or in boreholes.

Ramboll has conducted geophysical measurements for more than 30 years on various projects regarding:

- Infrastructure
- Environmental assessments
- Mining
- Oil and gas
- Offshore constructions (wind farms, cables, harbours etc.)

Ramboll is today Scandinavia's largest geophysical consultant outside the offshore and oil/gas industry.

Ramboll use and master a variety of methods, which means that we have the best opportunities to advise on the best method to be used for the various purposes.

Geophysical investigations
Geophysical services in Ramboll

Ramboll offers the following services:

Geophysical borehole logging

Seismic surveys

• Reflection and Refraction Seismic
• Shear and Surface Wave
• Borehole seismic (VSP)
• Crosshole Sonic Logging (CSL)

Electric and electromagnetic methods

Georadar, Metal detector and Gravity

Magnetic Resonance Sounding (MRS)

Marine surveys

• Seismic surveys
• Multibeam echosounder
• Bathymetry and Side scan sonar
• Cable tracking

Malmö Citytunnel Holma TBM Starting wall

Malmö Citytunnel. Cored 146mm borehole. Broyzoan limestone
Geophysical services in Ramboll

Borehole logging & seismic
- Logging truck

Offshore Measurements
- Storstrommen Bridge 2014

Georadar & Magnetic
- GPR 100MHz

Electrical and electromagnetic methods
- Slingram 6m depth
- SkyTEM

Seismic surveys
- Seismic profiles in 3D
- Landstreamer seismic

All examples in this presentation are from Ramboll projects

Geophysical investigations
Seismic Methods

Mapping of overburden, delineation of ore deposits, structures and faults in bedrock.

Ramboll offers a comprehensive suite of seismic methods:

**Land streamer vibroseis** – pioneered by Ramboll. High resolution shallow reflection seismic primarily performed on all types of roads. As well as off-road - depending on conditions.

**2D reflection P & S-wave surveys:** High resolution surveys with up to 120 channels, utilizing different sources: minivib (10-500Hz), explosives, accelerated weight drop or hammer.

**Refraction surveys:** mapping of top of bedrock both land- and marine survey

**Surface Waves surveys.** Very shallow (0-50m), mapping of overburden, calculation of geotechnical dynamic parameters

**Borehole seismics:** VSP or cross-hole tomography, calculation of seismic velocities, Crosshole Sonic Logging

**Marinstreamer – Multichannel seismic**
High resolution shallow offshore reflection seismic
Reflection Seismic – Landstreamer vibroseis

Example of land steamer reflection seismic recorded on road. The profile is 5km long and app 1km high. The purpose with the survey was to find sand/gravel structures which can be potential groundwater reservoirs. Example from south Jutland in Denmark.
Reflection Seismic - Carlsberg fault

Example of why it is a good idea to measure deeper than depth of construction. The fault (red lines) is 300m deep and can clearly be seen on the data. This would not had been seen if the investigation had only gone to the construction depth of 40-50m.

Ørestad Copenhagen. Recorded in 4 hours with crew of only 2.
The depth to limestone is interpreted to follow the 2500m/s line. Copenhagen centrum.

Tomographic Refraction analysis, first arrival picking from landsstreamer seismic

Helsingborg Sweden. Interpreted faults and structures. All profiles (roads) shown in 3D plot 4km long 2km wide.
Refraction Seismic - Depth to bedrock
An example of combining two methods to obtain useful information of the sub surface. Both methods is recorded along the same profile. Refraction seismic in the top, resistivity measurements in the bottom (Geoelectrical profiling).
Geophysical investigations

Geological profiles after interpretation of the sand structures. The original boreholes was not deep enough to reach the depth of the sand reservoir. The investigations resulted in new deeper boreholes to verify the results from the seismic data.

Surface Waves – MASW and S-wave Reflection

Formation parameters

The Shear wave velocity soundings used for geotechnical calculations overlaying a Shear (S) wave reflection profile. The example is from the port to the Storebælts tunnel in Denmark.
Borehole Seismic – VSP - Formation parameters

The dynamic parameters of the formation: G – Module, Young and Poisson ratio; can be calculated using the measured density and Shear (S-wave) and P-wave velocity of the formation.

For landstreamer seismic the VSP measurement is typical done using a Hydrophone cable with 20 hydrophones which is lowered into the borehole. The source is typical the seismic vibrator.
Borehole Seismic – Crosshole Sonic Logging (CSL)

Variations in the concrete in deep foundation piles and concrete walls can be determined by using a crosshole sonic logging system (CSL). Prompted by industry demand for a method to test the structural integrity of concrete in foundation piles Ramboll has invested in the SCXT3000 crosshole sonic logging system.

Based on the collected data Rambøll performs a thorough interpretation of each pile. This is gathered in a complete report where all interpretations are highlighted in text in addition to the interpreted individual profiles.
Geophysical Borehole Logging

Virtual core (3D caliper) from acoustical televiewer with results from optical televiewer folded around

Optical televiewer Borehole wall 360 degree
Geophysical Borehole Logging - Logs

A great advantage of borehole logging compared to core measurements, it gives a more complete continuous series of undisturbed measurements, no missing sections! Additionally it is much faster and cheaper!

Ramboll services includes: Geological interpretation, Hydrogeology, Physical properties, Elastic parameters, Fissure zones, Logstratigraphy, Optical televiewer – virtual core, Acustic televiewer, Deviation measurements

Example from shale gas exploration
Geophysical Borehole Logging - Flowlogs

Example from Malmö harbour and Malmö Cititunnel

On the background of app. 15 flowlogs, it could be documented that there would be a significant reduction in water-inflow, if the uppermost part of the formation were grouted.
Example of fracture analysis, comparing the core with results from logging with acoustical- and optical televiewer logs. Cityringen in Copenhagen
Geophysics – surface and airborne methods

**Resistivity - ERT/PACES/DualEM:**
Mapping of overburden and/or shallow targets in the bedrock

**Electromagnetic - TEM:**
Mapping of low resistive zones and mineralisations

**Airborne method - SkyTEM:**
Regional mapping

**Ground penetration radar - GPR**
Mapping of top of bedrock and shallow targets in the bedrock

**Gravimetric/Magnetometer:**
Regional mapping of structural features, high density ores or magnetic material
Geophysical investigations

Resistivity - Electromagnetic profiling – Slingram

Simple method for finding peat and other soft layer in an area down to app. 5m

Method for mapping of geological structures down to depth between 25 - 120m (depending on the field setup).

Resistivity - Geoelectrical profiling – CVES/ERT/IP
Resistivity - Electromagnetic profiling – DualEM

The Resistivity is recorded to 6 depths: 0.5m, 1m, 1.5m, 2m, 3m and 6m.

Interpretation profile with borehole.

Near surface resistivity mapping of a large area. Recording speed 10km/h, survey depth app. 6m.
Near surface resistivity mapping of a large area. App. 15km profile lines pr. day, survey depth 25m.
Resistivity - WalkTEM – TDEM Sounding

High shallow resolution combined with very deep penetration

Geophysical investigations
Resistivity - Helicopter EM - SkyTEM

Result, map showing variations in resistivity, used to interpret the presence of water aquifers (high resistivity - red color)

Resistivity mapping of a large area and along infrastructure (pipeline, roads). Survey speed up to 150km/h. Survey depth up to more than 500m.

Geophysical investigations
3D Ground Penetration Radar
Multiple possibilities for utilization

Road survey speed 70km/h
Concrete tunnel
Interpretated asphalt thickness

Rail survey speed 70km/h

Center channel. 21 channels spaced with 7.5cm

Surface map all channels, e.g. 0.3 m depth

Cross section

Center channel

Geophysical investigations
3D Ground Penetration Radar
Screening for possibilities for utilization and archaeological remains

Setup on cart for small areas and indoor. Vojens heating

Setup with ATV for larger areas

Remains from ring fortress - Denmark

Geophysical investigations
Ground Penetration Radar - Depth to bedrock

- The depth to the bedrock on Bog “Myr”
- 50 MHz and 100 MHz antenna with a estimated penetration up to 20 m
- Results: Depth Map

Andmyran Norway
GPR and reflection seismic - Depth to bedrock

Mapping the thickness of the Inland ice in Greenland using:

- Georadar 40, 80 and 200 MHz with an estimated penetration of up to 400 m
- Reflection seismic

Lot of Ice

Mount Isua Greenland
Geophysical investigations

**Ground Magnetic survey**
- Potassium GEM GSMP35,
- Caesium Geometrics G859A
- Proton GEM GSM-19TW

**Gravimetric survey**
- Gravity data. Bouguer anomaly

**Total magnetic field grid**

**Scintrex CG-3M (left)**
Elektromagnetic Metaldeetector – EM61

Mapping of unexploded ordnance (UXO) or metal constructions in the ground e.g. oil tank

Landfield area. Border recorded (red metal/green no metal)

The metal detector is used for control of the cleaning of old military fields, e.g. for placing of boreholes in the area. Another use is finding oil tanks on petrol stations and buried metal objects in fields

Old Military shooting field. Spikes are potential buried UXO
Laser scanning stationary, mobil on land and sea

MRS – Magnetic Resonance Sounding
Method to find groundwater aquifer before drilling

Geophysical investigations
Marine Geophysical Investigations

Ramboll has specialised in providing high quality marine geophysical investigations. Our services comprises acquisition, processing and experienced interpretation of Multibeam, Backscatter, Side Scan Sonar, Magnetometer, Single and Multichannel seismic.

**Bathymetry**

Dredging disposal site

**Side scan sonar**

Sand ripples to fine sediment

**Single- and Multi-channel seismic**

Multichannel seismic section, Sparker source, depth app. 300m
Marine Geophysical Surveys - Sub- and Seabed

New Storstrømmen Bridge 2014

Survey lines & Magnetic Objects
- Magnetometer

Depth to seabed (Bathymetry)
- Multibeam Echo Sounder

Seabed Classification & objects
- Side Scan Sonar - image of the seabed

Bridge trace

Survey vessel
- Easy mobilisation

Geological model - Depth limestone
- Refraction- and Multichannel seismic

Geophysical investigations
Cable and pipe tracking – Offshore and onshore

This survey provides confirmation of the position of existing cables buried in the seabed or beach and information of the seabed conditions using Electromagnetic geophysical instruments, Multibeam and Side Scan Sonar all mounted on ROV.
GOING GLOBAL
ENVIRON JOINS RAMBOLL

Further information:
Uffe T. Nielsen
Project Director
Ramboll Denmark
Phone +45 5161 6782
E-mail: UTN@ramboll.dk

Roger Wisén
Technical Manager
Ramboll Denmark
Phone +45 5161 6779
E-mail: RGW@ramboll.dk

Rune Jørgensen
Chief Project Manager
Ramboll Denmark
Phone +45 5161 6659
E-mail: RUBJ@ramboll.dk

Kristoffer Vrang
Head of Department
Ramboll Denmark
Phone +45 5161 6767
E-mail: KV@ramboll.dk

13,000 EMPLOYEES
35 COUNTRIES
300 OFFICES

Ramboll main markets
before acquisition of Environ.
Ramboll main markets
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Ramboll Environ main office.
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