



▶ Rail Tunnel Services



As a specialist supplier of rock engineering expertise, Golder RMT offers a unique range of rail tunnel related services and products which are increasingly in demand by Network Rail contractors and engineers.

Originally formed as a rock mechanics consultancy in 1994, we have seen a steady growth in rail related activity in recent years. Our office near Burton upon Trent has rock and support system testing facilities as well as geotechnical instrumentation development and production laboratories.

Our people have extensive experience in the following areas in which specialist sub contracting services are now being supplied to Network Rail contractors:

- ▶ Tunnel Condition Surveying: Lining or Rock;
- ▶ Tunnel Support Assessment and Design; and
- ▶ Tunnel Instrumentation and Monitoring;
- ▶ Rock Drilling, Coring and Testing.

Tunnel Condition Surveying: Tunnel Lining or Rock

We offer a condition survey for both unlined rock tunnels and those lined with brick or other materials using an Acoustic Energy Meter and Borehole Camera.

Acoustic Energy Meter



Acoustic Energy Meter

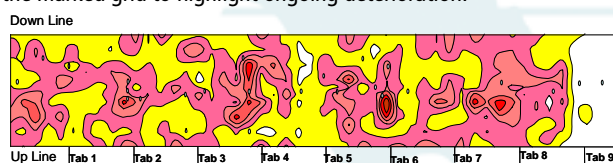
Until recently assessment of the condition of both unlined rock tunnels and tunnel linings was limited to visual inspection methods or use of GPR. Our own purpose developed instrument, the Acoustic Energy Meter (AEM) is used by our engineers to assess lining condition and detect voids and lining separation in rail, road, mine and water tunnels in the UK and worldwide. The AEM method has the advantages of being simple to carry out, easy to understand, and it gives a reading directly related to the physical condition or looseness of the lining. It is unaffected by water and other environmental factors. In addition we use a borehole camera system to record rock and lining condition in small diameter holes drilled through the lining.



Acoustic Energy Meter in use

The AEM comprises an integral microprocessor, geophone and readout unit with optional external geophone for remote operation. It measures reverberation decay rate of a surface when struck with a hammer. This parameter is insensitive to the energy in the blow, but sensitive to the larger scale soundness of the rock or lining, with loose or poorly supported structures vibrating longer than solid surfaces. The readout provides a normalised figure for lining or surface integrity with a high reading indicating loose, detached, fractured or poorly backfilled lining and a low reading for intact surfaces with no voids behind the lining.

We have developed a methodology for rapid consistent tunnel survey in larger dimension tunnels such as rail and road tunnels using the AEM, based on a grid marking system. Extension tools have been developed to apply the grid marks and obtain the AEM readings. Using these tools, allows rapid efficient survey of the complete tunnel surface with results displayed as contour plots. Surveys can be repeated using the marked grid to highlight ongoing deterioration.



Example of Results from an AEM Survey of a Rail Tunnel

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The above borehole camera stills show the lining/rock interface and void over lining in a rail tunnel.

Examples of recent UK applications include detection of voids behind a steel liner in a water tunnel at the Dinorwic Power Station, assessment of shotcrete adhesion in the Joskin Tunnel (Midland Quarry Products) and detection of lining separation in rail tunnels for Birse Rail, Disley and Sough Tunnels.

Borehole camera

Where small diameter open holes can be drilled for inspection purposes, we can view and record rock conditions using an in hole video camera system. This can be used to:

- ▶ Inspect voids and rock condition behind the lining; and
- ▶ Confirm the position of concealed construction shafts

The borehole camera system can be used in holes with diameters of more than 35mm. Depending on circumstances this system can be used to complement conventional diamond drilling and coring, especially where inspection of voids is desirable, or as an alternative method in open holes where core recovery is not needed.

The main application for this system to date in rail tunnels has been in confirming the position of voids behind the lining. This includes use in Belmont tunnel for Nuttalls and Lindal Tunnel for Birse Rail.

Tunnel Instrumentation and Monitoring

We have developed a range of innovative tunnelling instrumentation specifically to fit into small diameter holes 27mm, 32mm or 35mm, to make installation faster and easier. Our roof movement extensometers now come in many variants and can be visual indicators and/or electronic, locally or remotely read, single or multiple units. These are used in large numbers in mining applications and have application in confirming stability in unlined tunnels and acting as "bulge" or lining deformation meters in lined tunnels.

Of particular note is the new electronic extensometer system which combines high accuracy with low cost and local or remote reading options. The basic measurement principle used is that the inductance of a coil varies depending upon the position of a ferrite rod within the coil. This has the advantage over potentiometric devices of being contact-less, requiring very low power and not being susceptible to moisture. The signal conditioning electronics are well suited to an analogue, frequency based interrogation system. Numerous forms of this electronic extensometer are available based on a single basic transponder design with a range up to 75mm at 0.1mm resolution. Transponders can be interrogated remotely or locally with a portable readout unit which also provides the power source. They can be read separately, or connected together by a single cable to a central monitoring point.

We have both instrumentation production facilities and the capability to quickly develop new geotechnical instrumentation products to meet customer requirements. This highly unusual ability to produce 'bespoke' instrumentation products in a fast and cost effective way reflects both the expertise of our staff and the modular construction of many of our instrumentation systems.

Tunnel Support Assessment and Design

Our staff are at the forefront of developments in observational, classification based and computer numerical modelling methods of design for rock tunnels and underground openings, and can claim unrivalled experience in these areas. One of the areas in which our engineers specialise is in the development of site specific Rock Mass Classification (RMC) systems worldwide. These systems are based on the collection of geotechnical data by tunnel or excavation survey, and the assessment of this information in terms of ground control risk or tunnel support requirement. These activities currently form a significant part of the company's consultancy workload.





Reading instrumentation installed in one of the CTRL Tunnels

Although most of the tunnel support design carried out by our staff currently relates to international mining projects, UK civil engineering work is also undertaken. Recent examples include support design for the Joskin Tunnel linking two granite quarries (Midland Quarry Products), and for the Abbotscliffe Rail Tunnel adit (Nuttalls).

Support testing, both in the laboratory and underground and support performance measurement are an integral part of the design process and we have facilities to undertake the full range of strength and performance tests specified for reinforcement systems. The use of these tests allows an optimum system to be developed, tailored to a specific application.

Rock Drilling, Core Logging and Testing

Our engineers have many years' experience of the development and use of systems for maximising core recovery in weak mudstones in mining applications. Our specialist drilling systems have consequently been purpose developed to drill holes quickly through linings and weaker materials, using easily transportable equipment.

Small diameter open holes can be quickly drilled for inspection purposes or to install instruments, in addition to the more usual installation of support such as rockbolts. Where rock or lining cores are required, We prefer to use a small diameter thin walled twin tube core barrel such as the TT56, which produces 42mm diameter core. We also make use of a plastic barrel liner to maximise core recovery in weak and broken ground. The good core recovery obtained with the lined TT56 barrel avoids the need to take larger diameter cores, which inevitably take longer and require heavier equipment.



Extensometer Readout Unit



Weak Mudstone Core Obtained with a Lined TT56 Core Barrel

The main requirements for cored holes are to obtain core for rock or lining strength testing and to detail the lithology and condition of discontinuities. We offer a complete rock sample strength testing service to ISRM standards using in house testing facilities, and our geologists can advise and report on core logs, rock lithology and structure.

Our drilling expertise has been utilised in recent UK civil engineering and rail related projects in addition to international mining related work. These include large diameter drainage holes in chalk near Folkestone for *B&M McHugh*, ground investigation holes in the Strood-Higham rail tunnels for *Keller Group*, inspection of voids behind the lining in the Belmont rail tunnel for *Edmund Nuttall Ltd* and exploration drilling and coring in Nottingham city centre for *Ove Arup and Partners* and *Thomas Bow Civil Engineers*.

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