GBG Australia

Some of our work undertaken on tunnels:

Burnley Tunnel, Assessment of thickness, delamination, and condition
City Link Consortium / Mounsells (2004-2009)

Helensburgh Tunnel, Subsurface profiling of the tunnel lining and surrounding material
SMEC (2007)

M4 Toll Plaza Kiosk Tunnel, Tap testing and chemical analysis to assess corrosion levels and voiding behind corrugated iron
SWR Operations (2007)

Hazelbrook underpass, UPV testing of crack depths and extents
RTA (2007)

Lavender Bay Tunnel, Profiling of masonry lining and surrounding material
RailCorp (2008)

Mt Arthur Coal Mine Conveyor Belt Tunnel, Surface Penetrating Radar to map reinforcement detail
GHD (2009)

Redbank Tunnel, Profiling of masonry lining and surrounding material
GHD (2009)

Lillyvale and Bald Hill Tunnels, Profiling of masonry lining and surrounding material
SMEC (2009)

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Non-destructive methods for

TUNNEL INVESTIGATIONS

A number of methods are available to provide a means of obtaining information from structures in a non-invasive, non-destructive manner. Techniques including Surface Penetrating Radar, acoustic impedance and Schmidt hammer rebound hardness testing can all be performed under certain conditions on tunnel linings to provide our clients with the most accurate and cost effective investigations.

BRICK RAIL TUNNELS

Lining thickness

Overburden thickness

Assessment of moisture content and condition of lining

Condition of overburden fill material

CONCRETE ROAD TUNNELS

Determination of surface layer thicknesses

Determination of reinforcement detail and Depth of Cover

Location of Post-Tension cables and services

Concrete strength testing

Delamination of surface

Location of corrosion or voids/honeycombing

Assessment of moisture content or movement

Determination of cracking depths

Further information on our services, please visit our web-site: **www.gbgoz.com.au**

GBG Australia

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Non Destructive Techniques for

TUNNEL INVESTIGATIONS

GBG Australia

GBG Australia is a specialist in applying non-destructive investigative techniques for the assessment of buildings and structures. We offer our clients innovative methods of defining structural and condition information whilst minimising both costs and disturbances to the site.

Company Profile

GBG Australia is a subsidiary of the GBG Group, a multi-national company specialising in the application of geophysical and advanced applied physics for precision investigations of geotechnical, environmental sites and engineered structures in UK and Europe since 1982. GBG has had a presence in Australia since 1993 originally through a joint venture with CMPS&F and GHD before becoming a stand alone company in 2003, operating in three main areas of business: geotechnical and environmental investigations; non destructive investigation of structures and contracting of equipment and staff for data collection, processing and interpretation of data.

GBG Australia is an independent provider of non destructive and shallow geophysical investigation services with applications ranging from the location of a single pre-stressing strand in a concrete slab to mine scale exploration geophysics. With clients ranging from Local to Federal Government, and from developers and engineering companies to private individuals, we can provide tailored solutions to your particular subsurface investigation requirements.

Tunnel Investigations

Tunnel investigations can quickly provide an assessment of the tunnel condition and construction. GPR data collected along lines spanning the length of the tunnel and at points around the circumference. When processed the data can be used to map voids, liner thickness and condition, overbreak depth and fill material. GBG has had experience surveying both rail and road tunnels in a number of states. This method has proven to be more efficient than traditional coring and spot checking.

At a time when maintenance of existing infrastructure is becoming more important, Non-Destructive Investigation (NDI) methods can provide early detection of internal problems within a structure and can offer valuable re-specification of components from within a structure where for example, construction of tunnels followed few standards and age has not only caused degradation to the tunnel but also a lack of proper records. NDI methods are reasonably quick for data collection and, as the name suggests, do not damage the structure. These methods also supply far more information than a purely visual investigation which relies on the surface expression of subsurface problems and point examination methods such as drilling or coring.

Within this brochure we have presented a number of examples of the use of non destructive techniques for the assessment of tunnel structures.

Applications for

Non-destructive techniques

Brick Liner Rail Tunnel Investigations

ENTRANCE TO A BRICK LINED RAIL TUNNEL

Most railway tunnels are dug through rock and then lined with brick. The brick lining is many bricks thick and was expected to butt up against the lithology. The excavated tunnel of older railway tunnels, however, was rarely the exact same dimensions as the brick tunnel lining, which was often constructed with a free standing framework. The overbreak is the gap between the lining and the rock wall. This overbreak is often back filled with broken rock from the excavation.

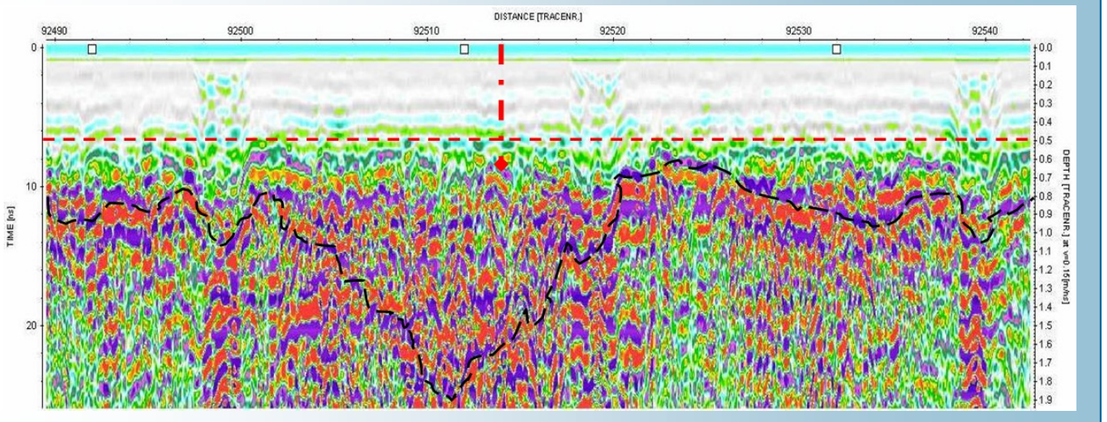
GPR profiling of tunnel linings has been a reasonably common place occurrence in the UK and Europe with work being undertaken on many of the old British rail tunnels between 1988 and today to assess lining thickness, condition and to pin point blind access shafts used in the original construction of the tunnels and sealed up after construction.

The GBG Group (of which GBG Australia is a subsidiary) has been undertaking tunnel lining investigations since 1988 and has completed investigations in approximately 120 tunnels to date.

Methodology

Data profiles are collected using a 400MHz-900MHz frequency antenna in parallel lines along the length of the tunnel at the Crown, haunch/shoulder, spring level and along the tunnel walls.

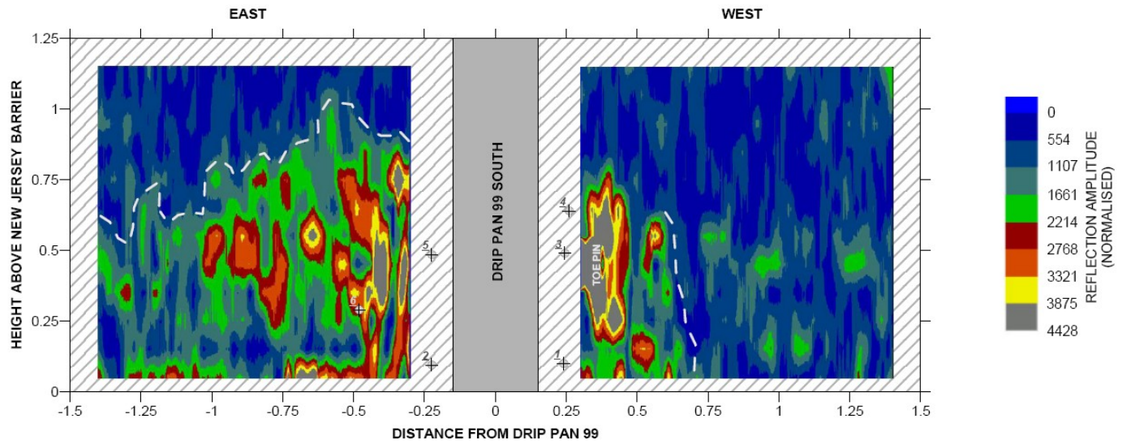
From these profiles the thickness of the liner (including the number of bricks used), the width of the gap between the liner and lithology and the condition of the lining material.



RADAR PROFILE SHOWING THE BACK OF THE LINING (RED) AND THE FRONT OF THE ROCK (BLACK). A LARGE VOID IS CLEARLY VISIBLE.

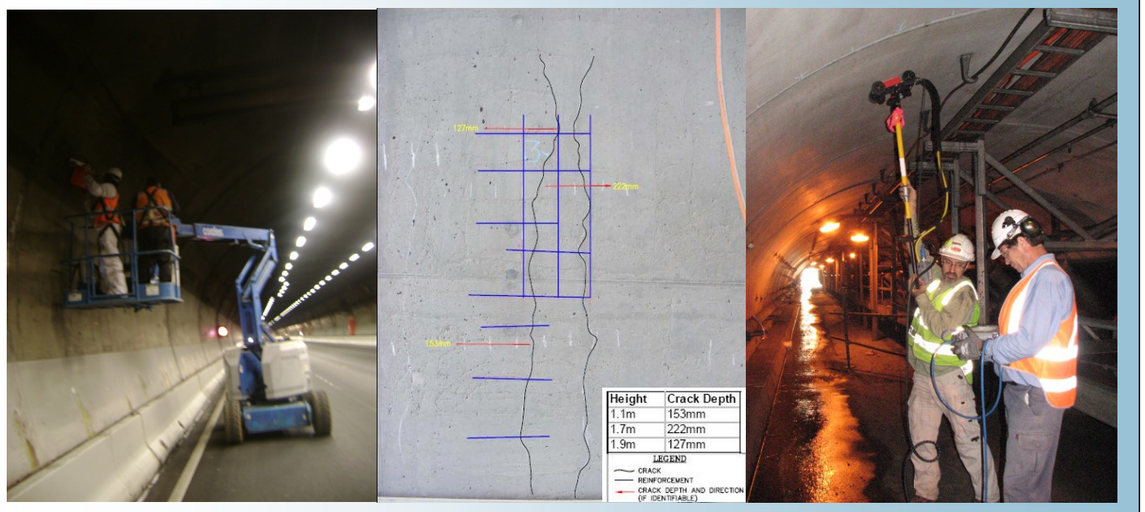
Concrete Lined Road Tunnels

There are a number of techniques used by GBG Australia that provide useful information on the construction of concrete lined road tunnels. Using Ground Penetrating Radar, Impact Echo, Ultrasonic Pulse Velocity (UPV) and Shmidt Hammer concrete thickness, delamination location and concrete hardness can be calculated.



THREE DIMENSIONAL TIME SLICE OF GPR DATA SHOWING HIGH AMPLITUDE AREAS (RED TO GREY) OF DELAMINATION AND LOW AMPLITUDE AREAS (BLUE TO GREEN) OF GOOD CONSTRUCTION.

Although concrete lined tunnels are expected to have a constant lining thickness errors in construction or degradation over time can cause faults in the lining thickness or integrity. If water unexpectedly leaks behind the lining then it too can have adverse effects on the tunnel lining. GPR is able to accurately determine the thickness of the lining, as well as detect areas where water has settled behind the lining. Areas where the lining is not consolidated will be detected as areas of high amplitude in the reflected data. Radar can also be used to detect the reinforcement detail and depth of cover.



<u>LEFT:</u> GPR SURVEY OF THE WALL OF A ROAD TUNNEL.
<u>MIDDLE:</u> RESULTS OF UPV SURVEY SHOWING CRACKS AND CRACK DEPTHS AND REINFORCEMENT.
<u>RIGHT:</u> GPR SURVEY OF THE ROOF OF A MINING CONVEYOR BELT TUNNEL TO DETERMINE REINFORCEMENT DETAIL.

Impact echo and UPV can be used to calculate the thickness of the concrete as well as detecting the size, depth and nature of delaminations and cracks in the lining material. These techniques as well as Shmidt hammer testing can determine the hardness of the concrete.