Homing in on hidden shafts

Archive data as obscure as an 1860s edition of the Hereford Times *and 21st first century GPR (ground penetrating radar)... This unlikely combination of old and new is helping to build a picture of the many obsolete construction shafts that lie hidden within railway tunnel infrastructure.*

What lies beneath... geophysical evidence produced by techniques such as ground penetrating radar (above) can help refine search techniques and thus save money.

THE NATIONAL TUNNEL MANAGEMENT STRATEGY (TMS) being implemented by Network Rail (NR) has precipitated the need to locate these shafts. TMS is part of a wider drive to improve the recording of the assets and related risks of the national rail infrastructure. As part of their commitment under TMS, the NR regions must identify all construction shafts, assess and manage the associated risks, and inform members of the public likely to be affected.

The shafts are relics of the rapid expansion of the rail network in the 19th century. Numerous shafts were sunk into hillsides to create work-faces from which to cut out and line the tunnel, and extract the spoil. Some shafts were retained for ventilation but many were capped at the top and blocked at the base. Not all were adequately recorded, and there are concerns about the risks they pose.

Water leakage is an on-going problem. The shafts provide a conduit for groundwater to run into the tunnel, potentially damaging the masonry lining and interfering with electrification and signalling systems. They also hamper commercial development of land above tunnels. Most worrying is the potential catastrophe of a shaft collapsing.

DETECTION

The soon to be five Network Rail regions are tackling the detection of construction shafts for TMS in different ways. Great Western Region (GWR) is undertaking a combined approach. This includes a desk study, visual inspection of tunnels from above and below, and a geophysical survey of masonry-lined tunnels requiring confirmation of shafts.

An intensive programme of asset research, dating back to 2001, had given GWR a huge advantage in building a picture of its construction shafts before the advent of TMS. A specialist researcher was even brought in specifically for the job.

Phil Roderick, Tunnel & Special Structures Engineer at Network Rail Great Western, says: 'We went through our in-house archives to find anything to indicate where backfilling of shafts has been carried out. Material may have gone astray during privatisation, so the research went much wider. Our asset researcher used record libraries, including the British Museum and Public Records Office, to track down evidence of tunnel shafts in our region. Sources included press reports, geological society reports on field trips, even contractors' diaries which recorded yardage of completed tunnel for the purposes of payment. For example, a report on the building of Ledbury Tunnel in an 1860s edition of the *Hereford Times* makes reference to the construction of an additional shaft to ventilate the works next to the main shaft. We had no record of this extra shaft until the archive research.'

IMPROVED COST CONTROL

What also stands out in GWR's approach is the early use of geophysics to help establish the likely location of shafts. Often, geophysics such as ground penetrating radar (GPR) is not considered until Approved Document stage, after initial evaluation has been completed. The perception is that by being very selective with GPR, you save money. GWR thinks differently, using a basic but sweeping geophysical review at the start to improve cost control across all elements of the programme.

Phil Roderick says: 'We are using geophysics up front to evaluate the accuracy of our archive data and extract value from it. The GPR is helping us to pinpoint the areas we need to worry about. It puts us in a position early on to make some qualified judgments about where to target money for further investigation and work.'

One reason for this confidence is the innovative way in which the GPR has been compiled with historic data by the project engineers, Donaldson Associates Ltd (DAL), and their appointed NDT (Non Destructive Testing) sub-contractor, Aperio Ltd. Aperio surveyed 51 masonry-lined tunnels in Great Western Region as the geophysical sub-contractor. With 15 years' experience of tunnel surveys, Aperio advised that a confidence rating should be applied to each result, based not only on the geophysical data but also on its correlation with historic data.

MOST RELIABLE PICTURE

Aperio Project Manager Mark Thomas, explains: 'Great Western's combined approach, using historic, visual and subsurface information, provided an opportunity to apply a "confidence rating" to the findings. We adapted our process to reconcile the GPR and archive data and grade them according to the degree of correlation between them. It was an effective way of giving the client the most reliable picture possible within the time and budget constraints.'

This methodology creates a value hierarchy for data, hung off a scientifically based framework – the GPR. When the GPR and documentation correlate strongly, a high rating is given. A low confidence rating is assigned where poor archive data is coupled with inconclusive GPR. The advantages for GWR are immense in prioritising early on where resources and budgets are best spent in the next phase of the programme.

Phil Roderick is enthusiastic: 'The reports look very good. They are simply presented and tie our documentation in with the GPR to show the basic nuts and bolts of Great Western's construction shaft legacy.'

TIME SAVINGS

Time savings are also significant. DAL and Aperio have wrung masses of disparate material of unknown reliability into an instant thumbnail guide to shaft inventory.

Phil Roderick remarks: 'The methodology of applying a universal confidence rating to data gives us consistency across the 51 tunnels surveyed to further guide our hand in prioritising subsequent work. We have a good idea of where we should be devoting resources and digging holes, and in what order of priority. Aperio's solution has been very successful, and is giving us value for money.

'We believe we have established a sound standard of practice for the rail industry in tackling the problem of construction shafts. It can be seen as a test bed for this sort of work.'

He adds: 'We are very confident that we are making real advances towards the truth of these forgotten shafts. The project is reinforcing the value of geophysical techniques, in the hands of rail specialists like Aperio, for the rail industry.'