# AVOIDING THAT SINKING FEELING

**Daniel McGrogan** reviews the use of laser scanning technology by The Coal Authority to probe incidents of ground collapse caused by one of Britain's oldest industries

The Coal Authority completes works to secure an unrecorded mine shaft at Kilbowie Road, Clydebank, in April 2017. Image: The Coal Authority

For the past five years, The Coal Authority – the public body that manages Britain's coal mining legacy – has been using laser scanning as an integral part of its ground investigation work. For particularly difficult projects that require precision surveying, engineers have found that specialist laser companies provide the 'go-to' technology they need for safer and more efficient working.

Compared to other investigation methods, and subject to site-specific conditions, laser scanning has proved to be the safer, more cost effective and a less disruptive option during complex ground investigations.

## Hidden voids

As part of its statutory duties The Coal Authority and its engineers have to deal with ground collapses, such as crown holes, depressions and open fissures. These incidents can be described in very much the same way as icebergs – what can be seen at the surface has no bearing on what can be hiding underneath, such as voids measuring hundreds of metres in depth.

Last year the organisation received more than 650 reports of surface hazards, each requiring an investigation to find out if it was the result of historical coal mining. Of these, 130 incidents were the result of shallow mine workings and 148 were associated with mine entries.

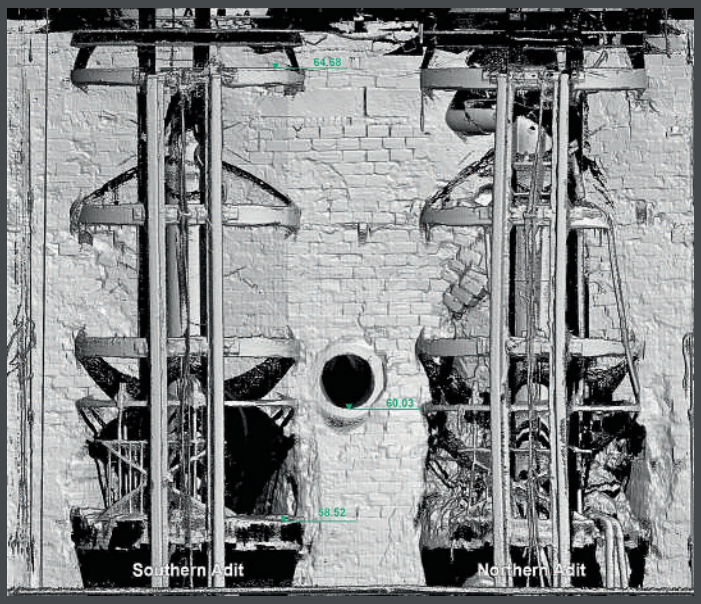
The typical size of a collapsed crown hole (a ground collapse caused by coal mining) is approximately 1.5 metres in diameter and typically reaches up to 30 metres in depth. These collapses, which are often complicated by the presence of service infrastructure such as utility pipes and cables, require detailed investigation to enable an engineer to design the correct solution.

This is where the laser technology comes into its own. Unlike CCTV, which is also used on a regular basis by The Coal Authority, laser surveys are geo-referenced to the Ordnance Survey National Grid and involve the calculation of exact measurements that provide a far more accurate picture of a ground collapse.

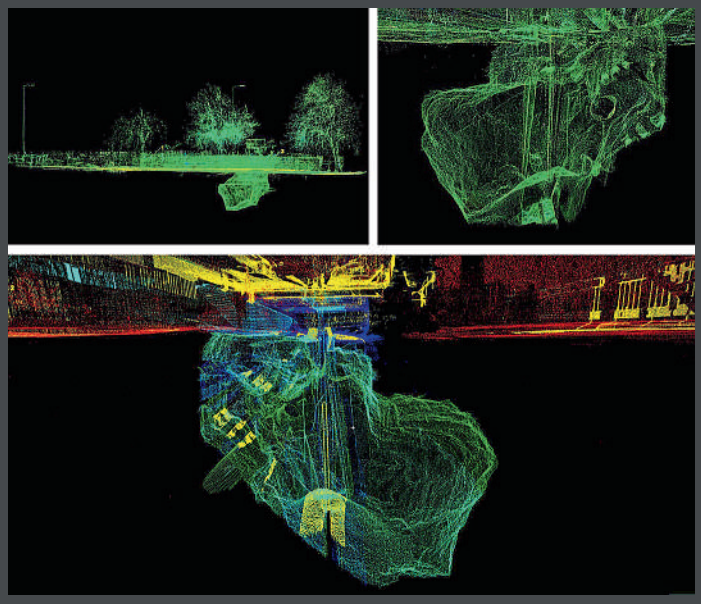
Such surveys are not only being used to investigate the extent and intricacies of ground collapses, but they're also monitoring the condition of abandoned mine shafts and mine entries.

## Assessing the risk

There are over 172,000 abandoned coal mine entries recorded across Britain. Nine years ago, The Coal Authority launched a mine entry inspection programme to visit and inspect mine shafts and adits (the name for a horizontal mine entrance). These sites can date from the 1800s to the present day, and because of the high




Laser scan of a former pumping shaft in north-east England that had partially collapsed helped engineers manage the collapse and design a suitable treatment solution. Photo: The Coal Authority



Laser scans of an unrecorded mine shaft collapse at Kilbowie Road in Clydebank, revealed that while only a six-metre diameter hole was visible at the surface, it hid a 200 cubic metre void that extended down a further 56 metres. Imagery: The Coal Authority

number, the inspection programme was prioritised depending on the level of risk.

It was during this mine entry inspection programme that saw The Coal Authority using laser imagery for the first time. In 2012, the organisation decided to put the new technology to the test when faced with a complicated assessment of a mine shaft. Two surveys were undertaken within this shaft 12 months apart, and showed places within the shaft's structure that were deteriorating and compromising its stability. This information enabled a shaft-specific safety management plan to be developed.

"It was hugely successful," said Phil Broughton, innovation manager at the Coal Authority, who adds,

"We now turn to laser survey suppliers whenever we are faced with complex, high-risk ground collapses. Last year we visually inspected over 20,000 mine entries and no two shafts are the same. Some require relatively simple public safety securing works; some are very complex and unique, and local ground conditions can mean varying conditions that require accurate referenced surveys.

"However, this new technology saves time and prevents long disruption to public networks because of extensive intrusive investigations. It allows Coal Authority engineers to prepare more accurate repairs to ground and shaft collapses and also saves money as more precise orders can be made for the necessary repair material, such as stone and grouts. This accuracy also plays its part in the budget process as the more complex calculations allow for more precise costings of the remediation materials. This is an important factor, as about 90 per cent of hazards cost around £10,000 to repair."

## Repair and remediation

Laser surveys also played a large part in the investigation and design of the repair and remediation of a complicated ground collapse that took place in January 2017 on a busy road in Clydebank, Scotland (see lead image).

Ground investigations revealed that the collapse was an unrecorded abandoned coal mine shaft extending to a depth of 62m from road level. The next phase was to design the solution, which began with laser scans of the void.

While only a six metre diameter hole was initially visible at the surface, these laser scans revealed that a 200 cubic metre void existed beneath the road surface.

The unrecorded mine shaft was revealed to go down yet a further 56 metres, meaning the depth of the mine shaft was the equivalent to the height of 14 double decker buses stacked on top of one another.

Crucially, this gave The Coal Authority the information it needed to establish an adequate safe zone, and meant it had the evidence to enforce a two-lane road closure to ensure public safety at the site.

The survey also enabled the shaft and subsurface utility infrastructure, exposed by the collapse, to be coordinated for Coal Authority engineers to design a solution that saw the shaft and void filled with 140 tonnes of stone, as well being injected with 217 tonnes of pressurised cementitious grout.

A reinforced concrete shaft cap then completed the works, which took nearly five months to complete. The survey was instrumental in ensuring that the public were not without public utility services, since the design could be positioned and planned accurately without severing or having to divert the utility services.

## Safe as houses?

In 2016, down borehole laser surveys were vital in confirming that damage to several houses was attributable to unrecorded coal mining beneath the area. Detailed analysis of the laser surveys revealed that the historical coal mine workings were also over-extracted in this location.

Specialist suppliers have used some of the latest laser innovative scanning survey equipment currently available to undertake subsurface laser scan surveys of voids, shafts and shallow mine workings in the UK on behalf of The Coal Authority.

The GeoSLAM ZEB REVO laser scanner was employed where a reasonably-sized access hole into the void was present and where the void was dry and between 40m and 150m depth below the surface. The MDL CALS laser scanner has been used where access has been through a minimum 80mm diameter borehole into dry voids. The FARO Focus 3D laser scanner has also been utilised where there is reasonable access into the void from ground surface to 40m below depth.

Where voids have been partially or fully flooded, the FLODIM multibeam sonar has been used to survey voids via an access hole at the surface and down a minimum 120mm diameter borehole.

Coal has been mined in Britain since Roman times and so, not surprisingly, its effects live on in Britain's coalfields areas, with laser scanning technology playing a vital role in managing this legacy.

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