

CASE STUDY

PFA USED TO INFILL DISUSED MINE WORKINGS IN THE WEST MIDLANDS

This bulletin describes how PFA grout was used to infill and make safe part of a limestone mine gallery formed during extensive mining activity across the whole of the Black Country in the West Midlands.



Background

The Black Country to the north of Birmingham was the heart of the Industrial Revolution. All of the ingredients of the early iron industry; coal, iron ore and limestone were mined locally. As a consequence, the area bore a legacy of abandoned mines and mine shafts. Houses, factories, shops and roads could all have been at risk and land that could otherwise have been developed was unusable.

Limestone caverns were the biggest problem because of the sheer scale of the workings. In Dudley alone, limestone caverns covered more than 136 hectares – 336 acres. Individual mine galleries could be 15 or more metres high, 30 metres or more wide and hundreds of metres long.

The network was so extensive that it was once said to be possible to walk underground the six or so miles between Dudley and Walsall.

The closer the caverns came to the surface, the more dangerous they were and many came within 30 metres or less. If the roof collapsed, the result would have been a crown hole. At best, it would be a circular pit 10 or 20 metres wide and one or two metres deep – at worst the resulting hole could have been 30 or 40 metres deep.

In 1978, major subsidence at Wednesbury damaged housing. It also blighted residential areas as potential purchasers fought shy of homes in an area of potential subsidence. The incident fuelled demands that at least the most dangerous of the caverns should be made safe.

After extensive engineering studies undertaken by Ove Arup & Partners, infilling with pumped PFA/OPC paste was chosen as one of the most practical methods of making the caverns safe. Over a period of four years, Generation Aggregates supplied more than one and a half million tonnes of ash for the infill projects.

Site works

Today it is normal practice to infill mine cavities by the injection of a PFA paste with a minimal quantity of added cement to achieve compressive strengths in the order of 1 to 2Mpa. However, one cavern situated below Dudley Castle and Zoo is unusual in allowing walk-in access. The cavern was stabilised in part using rock bolts to create a usable space but the northern third of the 2,000m long gallery was considered unsuitable for bolting for safety reasons. It was decided to infill this portion using a PFA paste.

To prevent a loss of usable underground space, a scheme was designed that incorporated a vertical wall of paste up to 15m high. The paste was pumped into the cavern along the main access tunnel via 200mm pipelines using a conventional concrete pump to pump over a distance of 200m.

A temporary retaining structure was required to hold the paste until sufficient strength had been gained for the face to be stable. It was decided that a system of rising shuttering would provide the best solution, with paste being pumped behind the shuttering in 1m 'lifts'.

Overnight strength gains were sufficient to allow the shuttering to be raised and the next layer placed. To ensure rapid strength gain, a cement content of 10% was required with water content being restricted to the minimum possible to maintain pumpability and flow characteristics.

The paste injection point was situated below the highest point in the mine to ensure complete infilling with the injection pipe being raised in conjunction with the shuttering. To prevent excessive weathering of the face when completed, a reinforcing layer of non-woven geotextile was included with each 1m layer of paste.

Why PFA?

PFA/cement paste with a low OPC content provided a low cost, low density fill material which could be pumped into the cavern.

By using a higher cement content than usual infilling applications, strength gains over a 24 hour period were sufficient to allow the use of a minimal retaining structure in an area of extremely restricted access and a very difficult working environment.



Acknowledgments

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Dudley Metropolitan Borough Council

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