



UNITED KINGDOM
QUALITY ASH
ASSOCIATION

CASE STUDY

Grouting of limestone caverns Mons Hill, Dudley, West Midlands

Using PFA/Fly ash for grouting

Pulverised fuel ash (PFA), known as fly ash in many countries, has been used for a number of years within the West Midlands area for filling old mine workings. Back in the early 1980's it became apparent that a major problem existed across the region from abandoned limestone mines. As a result a comprehensive government backed study was initiated to identify the full scale of the problem and consider a way forward. In view of the large volumes involved, the use of either natural virgin aggregates or traditional concrete mixes would have been inordinately expensive. Although PFA/cement grouts have been used extensively across the region for the treatment of abandoned coal mines and shafts they had not been used for large open void mine projects. Over the following years, cost effective mine infilling solutions were developed, including the use of PFA / cement paste based on a 50:1 mix. This PFA 'paste' has a relatively low water / solids ratio and satisfactory strength. Consequently, since the late 1980's continuing to the present day, a number of large scale infill contracts have been undertaken throughout the Metropolitan Boroughs of Dudley, Sandwell, Walsall and Wolverhampton in the West Midlands (UK)



Figure 1 - The Mons Hill grout production plant

together with Shropshire County Council. Initially the Department of Environment (DoE) funded these contracts, and more recently English Partnerships, under the Derelict and Natural Land Stabilisation programme, to remove the blight of these limestone caverns. Mons Hill mine, in Dudley, is one of a long line of projects completed in the region over the last 17 years.

The Mons Hill site is a nature reserve and an area of special geological interest. The fossils found in the limestone are considered some of the finest in the world, especially the ammonites. In addition, housing surrounds the nature reserve, so the highest standard of protection to the local environment was required. However, the mine under the site was in danger of collapse and infilling commenced in June 2001.



Figure 2 - A dust free stocking area



Figure 3 - The grout entering the Schwing pump

The materials

The PFA was supplied from PowerGen, Ratcliffe Power Station mainly from stockpiles. This material was pre-conditioned stockpile material, which is screened to remove lumps of agglomerated ash and then supplied in sheeted tippers as moistened materials. Typically 1,200 tonnes per day of PFA is used with a peak of 1,800 tonnes being supplied. The Portland cement used was Blue Circle CEM I 42.5N supplied into two 40 tonne silos.

Admixtures may be employed for some parts of the operation, for example, where barriers are required to prevent the grout from accessing some areas of the mine, accelerating admixtures may be used to reduce the setting times.

The total material usage is estimated at 200,000 tonnes of PFA for the contract.



Figure 4 - The dust free 'Groutmaster' plant

these belt weighers and the addition of water achieving the monitoring are made to ensure a well mixed, within specification product. The grout is regularly tested for flow and strength; however, the strength of the grout is typically only 0.7MPa. From the mixer the grout is fed to three Schwing concrete pumps, see figure 3. These pump the grout using a 125mm diameter steel pipeline to the injection points, see figures 5 and 6, which may be up to 1.5km from the production facility. This system can produce up to 3.5 tonnes per minute, or 1,900 tonnes per day, of grout.

Forkers Ltd have designed their 'Groutmaster' plant, where the grouting materials are never exposed to the air, ensuring dust free operation, see figure 4. The PFA is supplied dry in sealed tankers, similar to cement tankers. This is specifically designed for environmentally sensitive operations and can produce up to 300 tonnes of grout per day.



Figure 6 - One of the grout injection points

Producing the grout

Forkers Ltd is one of the main contractors who specialise in large grouting operations of this type. At Mons Hill a two-storey container wall surrounds the production plant, see figure 1, and material storage area. This provides good environmental protection, reducing dust and noise, and gives good site security. PFA is supplied in a moist condition and up to 1,800 tonnes may be stockpiled. In order to prevent dust a series of fine mist spraying nozzles are fixed above the stockpiles and production area, maintaining the PFA in it's moistened state, see figure 2.

The PFA is taken from the stockpile and placed in a hopper where, using a continuous weigh belt system, it is conveyed to a Belmix counter rotating paddle mixer. The Portland cement is laid onto the PFA on the conveyor belt using another weigh belt system. A computer automatically controls the required mix and flow properties. Records of production and



Figure 5 - Drilling the injection holes

Environmental monitoring

Because of the location of the site, its use and the requirements of the Environment Agency, Dudley Metropolitan Borough Council (DMBC) has carried out an Environmental Impact Assessment and comprehensive monitoring program. This involves the analysis of groundwater from numerous sampling points. Samples were taken prior to grouting and will continue for a long period of time to ensure no contamination of groundwater.

Because of the extensive precautions taken by the contractor, dust and water contamination from surface operations are minimal. In addition, the nature reserve wardens ensure the grouting operation does not impact on the wildlife and that nothing occurs that could put the reserve at risk.

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