SHORT COMMUNICATION

Backfill settlement of restored strip mine sites – case histories

Introduction

The paper presents an analysis of backfill settlement observations conducted upon a number of restored strip-mine sites in the North-East of England. The work is aimed at developing a better understanding of the stability of restored mine backfills from the point of view of structural development. The project is specifically concerned with the effect on fill movement of the re-establishment of the groundwater regime after the completion of surface mining and in particular the occurrence of collapse settlements associated with groundwater recovery within the backfill mass. Groundwater recovery commences on the termination of pumping in the area of the final void of a surface mine, although drawdown effects may have enabled the water to rise to some degree through fill which is distant from the final void. The rate of recharge is dependent on a number of factors, such as local hydrology, nature and permeability of the spoil and climatic conditions, (Singh et al., 1985a; Singh et al., 1985b).

The observation of backfill stability in the North-East of England started in the 1960s when Kilkenny (1968) investigated the suitability of restored surface coal mine sites for the purposes of structural development. He investigated relatively shallow backfill areas, and concluded that the settlement rates followed a semi-logarithmic decay with respect to time. A detailed investigation on an opencast site at Horsley, Northumberland, (Charles et al., 1977, 1983), monitored the effects of water recovery within the backfill on settlement rates, indicating principally the inducement of collapse settlements in backfill materials. The project also reported heaving movements associated with removal of fill surcharges and reduced settlement associated with presaturation of fill in the proximity of settling lagoons.

Site descriptions and results

The monitoring scheme on Site A commenced in early 1982. The site, a dragline operation backfilled in mid-1974, had a sandstone–mudstone type fill, the geological sequence worked being largely arenaceous. Two million tonnes of coal were extracted from the site at an overburden to coal ratio of about 20:1.

The project consisted of the monitoring of the settlement of a sewerage pipeline constructed...
over the mine backfill. Instrumentation consisted of the installation of three magnetic extensometers/piezometers in the fill complemented by three sets of 10 surface levelling stations. Manhole covers placed above the sewerage line also acted as surface levelling stations. The instrumentation layout is illustrated in Fig. 1.

The design of the pipeline was such that some degree of settlement could be tolerated by the introduction of flexible joints between individual pipe sections.

The time elapse between the date of backfilling, (mid 1974) and the commencement of monitoring, (early 1982) of 7.5 years was to prove extremely important in the analysis of the results to the present date. Movements have been recorded of up to a maximum of 15 mm; stations having shown either small settlement or heaving movements. The lack of water within holes E1 and E2 is in sharp contrast to the levels recorded on instrument E3. Fig. 2 illustrates the groundwater levels and settlement characteristics for instrument E3 against time.

Whilst trends would appear to exist between settlement and water levels from inspection of Fig. 2, it is considered dangerous and probably meaningless to 'over-analyse' these results. Movements of fill in the region of ±12 mm in about 16 m of fill depth show for the purposes of this exercise that the pipeline is not being subjected to adverse differential backfill movements. Little correlation can be drawn between recovery and settlement and this is probably due to the fact that monitoring commenced 7.5 years after backfilling had been completed. From the E3 instrument results, however, it can be stated that after an uncertain time period a fluctuating water table will cease to cause further significant collapse settlements.

Site B was worked between 1957 and 1973 producing about 7 million tonnes of coal from a dragline operation. The backfill is a typical sandstone/mudstone fill common in the area. On the completion of areas of backfilling, three surface levelling traverses were installed. Fig. 3 shows the position of the main traverse together with approximate depths of fill, and piezometer location (A).

The water levels at the piezometer are illustrated in Fig. 4a. The figure shows that the water levels over this part of the site were recovering slowly from the start of monitoring up until May/June 1982. Fig. 4b shows the settlement versus time curves for all the stations over the traverse. It can be seen that settlement rates retarded around the time of the completion of groundwater recovery thus indicating that settlement and groundwater were related. Following recovery, the groundwater levels can be seen to be dropping and this corresponds to a period of

![Fig. 1. Instrumentation layout at dragline site A.](image-url)