Technical Article

Strata Monitoring Investigations Around Longwall Panels Beneath the Cataract Reservoir

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Abstract. This paper describes the extraction of longwall panels in the Bellambi West Colliery beneath the Cataract water reservoir in the Southern Coalfields of NSW. These longwall workings were designed in accordance with the statutory conditions imposed by the Reynolds Commission of Inquiry, 1978, and worked in accordance with the conditional permission given by the Dams Safety Committee. The major conditions under which mining was permitted included: (a) submission of periodic mining plans identifying the geological structures encountered, (b) monitoring of strata behavior around mine workings and (c) water balance studies to be carried out in the mine workings beneath the water reservoir. The main monitoring program consisted of monitoring of geological structures, observation of the water seepage into the mine workings together with their sediment contents, and the measurement of surface subsidence and sub-surface strains. In addition, piezometric levels in the boreholes overlying the production districts were measured showing the fluctuation of the ground water level. Stress/deformation measurements were made on the longwall chain pillars to indicate their structural stability.

Strata monitoring during the first three years of workings under the Cataract reservoir have indicated that the surface and subsurface subsidence and the strata displacements were within permissible limits and no water inflow was encountered as a consequence of coal mining under the Cataract reservoir. Based on these studies, the life span of the mine has been extended by eight years.

Key words: Australia, Illawarra, ground strains, longwall mining, subsidence, underwater workings.

Introduction

Underground coal mining in the Illawarra region is being carried out in the Bulli Seam by 11 operating collieries producing some 18 million tonnes of coal per year. One of the main features of this coalfield is that mining is carried out in an environmentally sensitive area within the catchment area of the Sydney Water Corporation. A large amount of coal had been sterilized in barrier pillars below major water reservoirs and dams. Since 1978, coal mining has been allowed in the restricted area (in the close proximity of dams and water reservoirs), with the approval of the Dam Safety Committee.

Permission for mining under major reservoirs and dams is granted by the Dam Safety Committee under conditions based on the recommendations of the Reynold’s Inquiry Commission (1976) and the Dam Safety Act (1978). In this paper, a case history is presented where permission was sought from the Dam Safety Committee to mine coal reserves under the Cataract Reservoir by the mechanised longwall mining method.

The paper describes a wide ranging monitoring program implemented by the mine operator during the first three years of the workings in order to carry out safe mining under the Cataract reservoir (Jakeman 1996). An instrumentation scheme was installed that included monitoring the surface subsidence by precise surveying, measuring ground strains and strata displacement using borehole extensometer surveys above the coal seam, monitoring of the pillar stability parameters within the coal seam, piezometric surveys in boreholes above the longwall panels, and monitoring of water inflow and pumping quantities in the longwall panels below the Cataract Dam. During the first 2.5 years, 30 km of roadways were developed in 6 longwall panels and approximately 2.5 million tonnes of raw coal was extracted from four longwall faces each being 110m wide supported by 66m wide chain pillars.

Factors to be considered for the design of mine workings under stored water

The main objective of mining under bodies of water is to safely extract as much coal as possible without
disturbing the overlying strata to a degree that water inflow to the mine workings becomes excessive. There are two main possibilities relative to the inflow of water. The first is water ingress through pre-existing arrays of discontinuities or through geological structures such as dykes and faults. The second possibility is that water enters the mine through tensile zones that may be created by the subsurface subsidence associated with longwall mining. These factors have been considered in detail in previous publications (Singh 1986; Singh 1989; Singh and Akins 1982; Singh and Kendorski 1981; Whittaker and Singh 1978; Whittaker et al. 1979). The main considerations that govern the design of mine workings under bodies of water are:

(a) The geometry of workings and its effect on the possible development of a de-stressed zone between the mine workings and the water reservoir,

(b) Thickness of barriers between the reservoir and the workings,

(c) The nature of rock material in the barrier (mudstone, shale and claystone)

(d) Strains at the bottom of the bodies of water, and

(e) Geological features such as faults, dykes and joints forming conduits of water.

Mining at Bellambi West Colliery

Bellambi West Colliery is situated in the Southern Coalfields of NSW about 14 km west of Wollongong. The mine is over 100 years old and has produced some 60 million tonnes of coal since its inception and provides nearly 300 jobs. The colliery also indirectly creates about 1000 other jobs in the area due the continuous operation of the mine. Approximately A$ 52 M per annum are injected into the local economy through employees wages, direct and indirect taxes and the purchase of goods and services. In the late 1980’s, good quality coal started to be depleted in the western district of the colliery and the quality requirements of an international customer could not be met. The best quality reserves were locked up under the Cataract Reservoir as a coal reserve in the restricted zone. In 1990, the management applied to the Dams Safety Committee for permission to mine coal reserves under the Cataract Reservoir. In May 1991, the Minister of Mineral Resources permitted extraction of the first seven panels and the development of the eighth panel based on the recommendations of the Dams Safety Committee (Figure 1). The Chief Inspector of Coal Mines subsequently approved the extraction of the first seven panels by the longwall system of mining. The development of roadways in the Cataract district commenced in March 1992 and by March 1993, the development of the first longwall panel was completed. Mining in the Western District ceased completely in June 1993 and panel 501 in the Cataract District commenced production. Since then, the entire production of the colliery comes from the Cataract District (Jakeman 1996).

Conditional approval for longwall mining

In an initial plan of the first 8 faces, a 105m wide face was developed with 70m wide rib pillars. In the subsequent design, a face width of 115 m together with 65m x 100m size rib pillars was incorporated in the mine plan (Figure 1). It may be noted that the minimum depth below the surface was used to calculate the panel width. In contrast, the maximum depth of the panel was used to calculate the width of the rib pillar with widely spaced cut-throughs.

During periods of longwall extraction, the following monitoring programs were implemented:

(a) Underground seam mapping to extrapolate the known geological features that may influence the stability of the strata below the reservoir.

(b) An in-seam seismic survey using boreholes within the seam to identify any structures that may lie within but had not been revealed by previous extraction from areas around the reservoir.

(c) A detailed surface subsidence grid to accurately measure subsidence around the perimeter of the reservoir.

(d) Monitoring to measure water inflow to the mine by means of water balance studies of underground operations. The quantities of water used in the mine for dust suppression and drinking and the quantity of water pumped out of the mine during the normal operation of the mine were all measured. Any increase in the difference between water used and water pumped out could be attributed to inflow from the reservoir to the mine through arrays of mining induced fractures.

(e) In-situ strain measurement was carried out on the dam structure using strain gauges capable of measuring strain up to an accuracy of 0.1mm/m.

(f) Ground water monitoring using piezometers to measure variation in water pressures contained within the strata above the area to be extracted.

(g) Pillar loading and deformation using stress meters to ascertain whether the chain pillar remaining after longwall extraction deformed as a result of extraction.