Engineering Failure Analysis 67 (2016) 15–32

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

# Failure analysis of a large span longwall drift under water-rich roofs and its control techniques

Qing-Sheng Bai *, Shi-Hao Tu

*Key Laboratory of Deep Coal Resource, Ministry of Education of China, School of Mines, University of Mining and Technology, Xuzhou 221116, China*

ARTICLE INFO

*Article history:*
Received 9 March 2016
Received in revised form 9 May 2016
Accepted 19 May 2016
Available online 20 May 2016

*Keywords:*
Failure analysis
Large span longwall drift
Water-rich roofs
field Observation and numerical modeling
Control techniques

ABSTRACT

In this study, failure analysis of a large span longwall drift under water-rich roofs was presented relying on field observations and numerical simulations. We had sought to find the key points that caused the drift roof collapse and water inrush. The numerical results were similar with that observed from field situations, and they both determined the origins of the roof failure problem. Wrong location selection and unreasonable excavation and support schemes were verified to be the most important factors that caused roof failure of the drift. Subsequently, a new excavation location with poor roof aquifer was recommended. A two staged excavation procedure was employed. Firstly, a small span roadway was excavated and reinforced, then the roadway was widened to the design width. After the first pass, boreholes were drilled to dewater the roof aquifer, and chemical glue material was grouted into the roof to cement the pre-existing discontinuities and induced fractures. Such control techniques had been undertaken in the new longwall drift. Both numerical modeling and field measurement verified that the proposed method could guarantee the large span drift stability during excavation and longwall preparation period. The interest of this study resides in combining the integrated methods to evaluate the state of failure in a highly detailed manner and determine simultaneously control techniques for the thorny problem under study.



## 1. Introduction

In China, a large span roadway in underground coal mine is commonly defined as any roadway that is driven to a width >5.0 m. These roadways are typically excavated to install longwall equipment (termed longwall drift) and prepare the longwall retreating; however, other applications include the need to house conveyor driveheads and pre-driven longwall recovery roadway. Conventionally, longwall drifts are 5 to 8 m wide. As a result of the increasing size of longwall equipment and mine infrastructures, drift widths between 9 and 14 m are being developed in some cases. For time and cost consideration, sometimes the large span drifts are excavated as the design size in one pass. But when severe ground control issues occur, large span drifts are driven in two or more passes. The first pass is a small span roadway, in most cases which is the normal roadway width at the mine. When the first pass is driven to the expected length, the roadway is then widened to the design width.

General buckling beam theory indicates that the capacity of any beam in the roof will reduce in inverse proportion to any increase in roadway width squared [1]. It means that the greater the final width of the roadway, the larger the resulting surge in roof displacement and the more the likelihood of roof instability, which has been verified by many field practices [2–7]. In fact, roof movement is often together with increased beam breakdown in the lower roofs and the induced fractures progression

* Corresponding author at: School of Mines, China University of Mining and Technology, Xuzhou 221116, China.
*E-mail address:* qingsheng_bai@yahoo.com (Q.-S. Bai).

http://dx.doi.org/10.1016/j.engfailanal.2016.05.028
1350-6307/

into the upper roofs, which also relies on the quality of the strata and roof reinforcement schemes. To increase the roof stability, wide roadways should be driven at least two passes. This roadway excavation scheme has two virtues. The small span roadway in the first pass induces small roof displacement and then roof stability can be guaranteed. The first driven also offers enough time to reinforce the roof with a high standard ahead of widening, such that the reinforcement can allows the roof in the first pass to better tolerate the resulting sagging during the following passes. On the other hand, the first pass could explore the geology in the design location. If the roof has an inherent high degree of stability, one pass excavation can be practiced to reduce the time and cost.

There exists a tendency in China that coal mining goes to deep resources. Under the influences of high in-situ stress, high permeability, complex aquifer environments, and strong mining disturbances in deep complex geological conditions, roadway stability suffers many difficulties and huge cost. Thick coal seam contributes approximate 45% of China's coal production in more recent times [8]. At present, more than 100 longwall top coal caving (LTCC) faces are working in China. In LTCC faces, most roadways and longwall drifts are driven locating on the floor of the thick seam and thus forming a coal roof. Thick top coal above the roadway is easy to damage, fail and produce large displacement and roof accidents after roadway excavation, particularly when the roadway has a large span in high underground stress environment. So longwall drift roof failure in LTCC face is a significant safety and productivity issue facing by the Chinese underground thick coal seam mining industry.

Underground water is another key factor that affects the stability of wide drift. Local groundwater flow into roadways is a technical problem for underground constructions, which may lead to potential hazards and is an important factor influencing construction time and stability and resulting in a global increase in the construction costs [9]. Some of these geological features and its related disasters have been frequently reported in underground coal mine roadways in China [10–12]. Therefore, it is essential to have a careful consideration of the groundwater inflows before and during excavation of roadways, particularly when there is

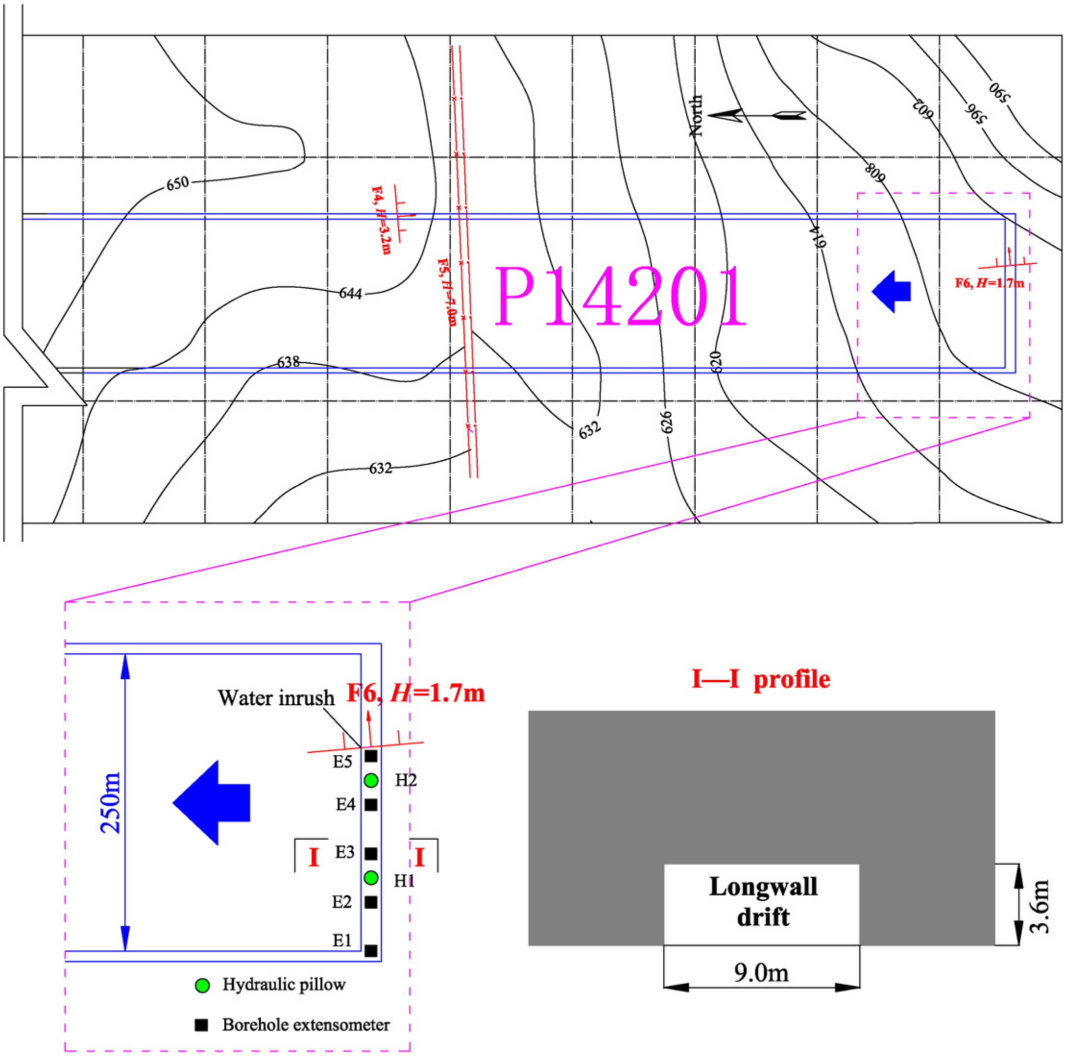


**Fig. 1.** P14201 and the longwall drift accompanying with the water inrush area and borehole extensometer and hydraulic pillow locations.