The Water Prediction and Control Engineering Project for Roadway through Badly Sealed Boreholes

— with Sijiazhuang coalmine of Yangquan Coal Administration as example

Hujun Ren*, Peng Qinga, Yuchun Wanga, Yi Wangb, Jianjun Duana

*Hydrogeology Bureau of China National Administration of Coal Geologic, 056000, Handan, Hebei
bShanxii Yangquan Coal Administration, 045000, Yangquan, Shanxi

Abstract

Badly sealed boreholes water inrush is one of big hidden dangers to coal production safety, this paper mainly studied water prediction and prevention engineering for roadway badly sealed boreholes in Yangquan Coal Administration of Yangquan Coal Administration, analyzed the range of the borehole deflection and delimitation of waterline, presented technical means and solution. The research provided a technical method for water prediction and control in similar projects.

Keywords: badly sealed boreholes; prevention and control engineering project; water rupruption danger; calculate range

According to the water-bursting disaster types, coalmine explore water-bursting disaster divides into cranny water inrush, goaf water inrush, caving zone water inrush, collapse column conduction, fault water inrush, badly sealed boreholes water inrush. Recently because of badly sealed boreholes underground water inrush disasters often occurs, such as Na Linhe coalfield, Mu Duaideng coalfield, these coalfields happened water inrush disasters at roadway drilling and tunneling Engineering because of badly sealed boreholes. Some coalfields make a quality inspection for the drill hole by sampling method, discovering that sealed boreholes quality conformity rate is 60%. These questions appear the primary cause includes: sealed length isn’t enough, go without pouring in sealed material, the exposed stratum isn’t in accordance with Detailed Exploration Report. There are some boreholes passed examination, but

* Corresponding author. Tel.: +86-310-8348808; fax: +86-310-6091212
E-mail address: rhj288@sohu.com
for reasons that the under part of sealed section’s depth doesn’t reach the enclosed pervious bed, existing insecurity in coalmine exploiting, are unqualified boreholes. Therefore, badly sealed boreholes as a big hidden disaster are being concerned.

This paper takes badly sealed boreholes in Sijiazhuang coalmine of Yangquan Coal Administration as example, explains engineering project methods and some problems worth of attention.

1. Engineering project general situation

Sijiazhuang coalmine is located in Xiyang County of Shanxi Province, is the infrastructure mine of Yangquan Coal Administration, an area of 124 square km², annual production capacity is 5Mt.

According to exploiting planning, constructing subsidiary transportation roadway, belt conveyor roadway, eastern ventilation roadway at the north flank, these roadways are in the place of the roof and floor strata of the Carboniferous Taiyuan Formation. In the front of the three piercing roadway, 1326# borehole was completed by a geology company in 1960(Fig.1). 1326# borehole ended about 10 m below 15# coal seam floor. The location of this borehole isn’t clear because it doesn’t measure the slope level with quality. Therefore, because of the exiting badly sealed phenomenon, it risks the break over of water-bearing bed above coal stratum and impoundment water when main roadway pierces at the place of 1326# borehole. Qin Shan impoundment water will produce about 4.2Mpa head pressure to 15# coal seam,, making water-bearing bed above coal stratum more watery, when water inrushes the consequence will be disastrously if there is no advance prediction and prevention.

It needs special project to ensure north flank main roadway across 1326# borehole, to confirm 15# coal seam location and watery situation along 1326# borehole.

2. 15# coal seam roof, floor and hydrological characteristic

2.1. Coal seam and roof, floor

15# coal seam in Sijiazhuang coalmine is located 18 m below Carboniferous K2 limestone K2. It is a stable and thick coal seam in the region. Coal seam thickness is 2.79~7.40 m, average is 5.12 m, 5.5 m in borehole1326#, coal gangue average thickness is 5.67 m. Ordinarily coal seam contains 2~4 layers of coal gangue, 6 layers at most, coal gangue lithological characters are mudstone and carbonaceous mudstone, roof lithological characters is sandy mudstone or siltstone. Floor lithological characters is carbonaceous mudstone, sometimes is sandy mudstone or siltstone. 15# coal seam direct roof lithological characters mainly is sandy mudstone, thickness is 3~5 m, pressive strength is 12~41.9MPa, collapse of roofs is easily; main roof is comprised of marlstone, sandy mudstone and limestone, pressive strength is 37.3~95.7Mpa. 15# coal seam floor lithological characters mainly comprise mudstone sandy mudstone and siltstone, floor rock uniaxial compressive strength is 6.7~90.1MPa, mostly is greater than 30MPa.

2.2.15# coal seam floor hydrological characteristic

Above 15# coal seam floor has three layers of limestone: K2, K3, K4, average thickness is 33 m. K2 quality is pure, has a stable horizon, always divide into 3~4 layers by mudstone, thickness is 0.95~6.60 m, average is 4.40 m. K3 also has a stable horizon, comprise mud and abundant biodetritus, thickness is 0.30~8.10 m, average is 4.1 m. K4 quality is impurity, has an unstable horizon, average thickness is 1.90m. karst, solution crack forms the dominant part, has pores and small cave. Crack and pores occur widely in shallow borehole, but it’s undeveloped in deep gradually. According to pumping test in Taiyuan
Fig. 1. The location relation between roadway construction and 1326# borehole
Formation, specific capacity is 0.020L/s.m, with small water yield low water-richness, and shows parabolic curve, the level is easily resume after pumping water, it illustrates that the permeability of water-bearing stratum is relatively strong and rich in supply conditions.

3. The prevention and control engineering project

It needs special project to ensure north flank main roadway across 1326# borehole, the technology method as follows: ascertain the accurate range of 1326# borehole in 15# coal seam; calculate the width of waterproof pillar in accordance with Coal Mine Water Control Stipulation, mark the range of waterline and detect water warning line; use geophysical prospecting method to delineate water-collective area, use underground drilling prospecting and drainage water to seal aquifer.

3.1. The range of 1326# borehole deflection in 15# coal seam

Because it didn’t measure 1326# borehole slope level with quality in 1960, according to Specifications for Coal, Peat Exploration, the borehole depth calculates by 450 ms, the max borehole slope is 1°/100m, result displays that the displacement of 1326# borehole deflection in 15# coal seam is 30.76m. Due to drilling equipment and technique, borehole deviation may exceed current standard request, concerns about the problem in insufficiency angle, the coefficient of 1326# borehole displacement deflection in 15# coal seam was calculated by 1.5, prediction result of borehole displacement was 46.14m (Fig.2). The result refers to the problem that the possible displacement range of borehole in 15# coal seam was as the centre with 46.14 m for the radius of a circle.

3.2. Calculation of the width of waterproof pillar

According to Coal Mine Water Control Stipulation appendix III, the computing formula of coal waterproof pillar for watery or water-conducting borehole is as follows:

\[ L = 0.5KM \sqrt{3P/Kp} \quad (\geq20m) \]

Where: 
K——safety factor, value range from 2 to 5;
M——coal seam thickness or mining height;
P——head pressure, MPa;
kP——tensile strength of coal, MPa.

According to the strata characteristics and coal types of Yangquan, the formation of strata is relatively complete, safety factor value 4, coal seam thickness value 5.5m, head pressure value 4.2 MPa, the type of 15# coal seam is anthracite, tensile strength takes up about 1/10 of pressive strength, according to the value of pressive strength in geologic report, tensile strength value 0.46 MPa, calculating result shows L=57.57m.

3.3. Waterline and warning line identification

The probable range of borehole is about 46.14m, and the width of waterproof pillar is 57.57m, the sum of their value is 103.71m as the extent of waterline. The range of warning line extends 40~50m on the basis of waterline.
3.4. Technical method

Underground geophysical prospecting and drilling were used to predict and control water inrush. Observation stations of underground transient electromagnetic method (TEM) and drilling sites were set. According to the demand of Coal Mine Water Control Stipulation, 12 underground TEM observation stations and 7 drilling sites were set.

The exploring orientation of TEM, see fig.3, 4, 5.

According to the water prediction and control plan, underground advance drilling must comply with long distance detection and short distance driving, that is, 100m was detected, 50m was driven. Geophysical explanation was used to adjust and construct underground boreholes, borehole for detection of aquifer should be drilled along left roadway’s wall diagonally, the target position is the water-bearing
stratums above 15# coal seam, that is roof sandstone and K2 limestone, drill-hole finished when it entered into K3 limestone. The borehole depth can be directly calculated. According to the request of Coal Mine Water Control Stipulation for water detection, borehole was well sealed on the basis of water-bearing stratum pressure. Borehole should be sealed by grouting after water drainage, grouting pressure was not less than 1.5 times of water-bearing stratum static pressure.
4. conclusion and suggest

(1) The water prediction and control engineering project estimates the probable deviation distance of 1326# borehole in 15# coal seam, calculates the width of waterproof pillar, delineates water warning line and detecting line. The research provides a technical method of water prediction and control to similar projects.

(2) Underground geophysical prospecting and drilling were used to predict and control water inrush effectively, north flank ventilation roadway smoothly is getting through the danger zone at the present time.

References:
